POWER PLANT ENGINEERING

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New Plant of the Badger State Tanning Co.

INCREASED ECONOMY IS OBTAINED BY THE USE OF UNAFLOW ENGINES

SINCE THE TIME, about 2 yr. ago, when fire destroyed the larger part of its tanning plant, the Badger State Tanning Co., of Sheboygan, Wis., has been engaged largely in reconstruction work and has evolved a plant which merits some consideration.

For the reason that the operation of the plant demands a large amount of exhaust or low pressure steam for process work, the plant generates its own power, instead of generating steam at low pressure and purchasing the power from an outside source.

In the present plant as in the old, all machines are operated by individual motor drives. The original plant was equipped throughout with direct current apparatus, the current for which was supplied by d. c. generators, direct connected to slow speed, four-valve engines.

In building the new plant, the direct current system was discarded and an alternating current system installed. Now all machines are driven by squirrel cage induction motors with the exception of a few cases where slip ring motors are used for variable speed work.

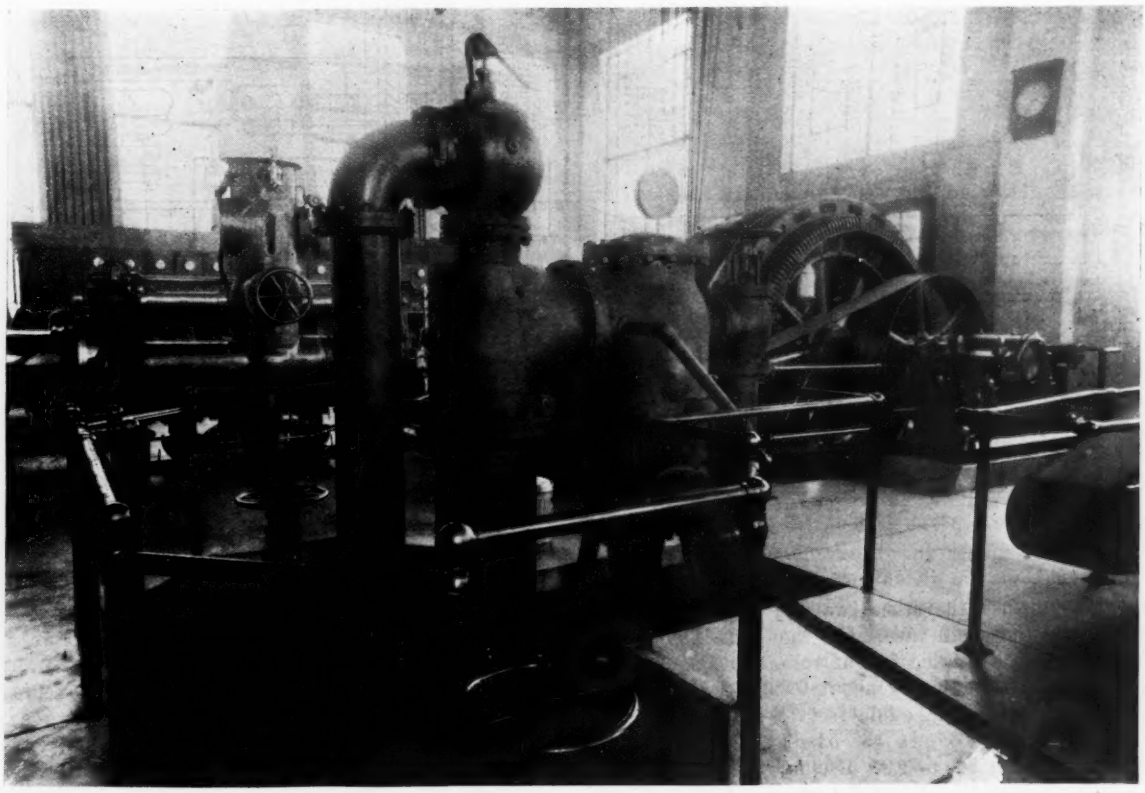


FIG. 1. VIEW OF THE ENGINE ROOM SHOWING THE JET CONDENSER IN THE FOREGROUND, WHICH MAY BE USED WITH EITHER ONE OF THE TWO ENGINES

All equipment is operated on 440-v., 60-cycle current.

This current is supplied by either one or both of the two 750-kv.a generators which are direct connected to 750-hp. unaflow engines.

Steam is supplied by three water-tube boilers having a total rated capacity of 1368 hp.

Boiler Room

Number 1 boiler, at the west end of the building, is a Stirling, rated at approximately 500 hp. The total effective heating surface amounts to 5093 sq. ft. Tubes are arranged in banks 25 wide across the furnace which is 12 ft. 6 in. in width. Number 2 boiler is a 500-hp. Edge Moor, having approximately the same amount of heating surface, and No. 3 is a Stirling 368-hp. unit, having 3677 sq. ft. of surface.

All three units are equipped with Detroit "V" type overfeed stokers. The first two have grate areas of 89 sq. ft. each and the third, 61 sq. ft. The volume of the combination space is about 1000 cu. ft. on the first, 1100 cu. ft. on the second and about 600 cu. ft. on the third.

It will be noticed that the ratio of furnace volume to heating surface is somewhat greater on the No. 2 unit than on either of the other two and that this ratio is smallest on the small unit. On the unit having the largest volume the cubic feet of volume per square foot of heating surface is only about 0.22 and the ratio of the furnace volume in cubic feet to the grate surface is about 12.5 to 1.0. In the small unit, this ratio is reduced to about 9.5 to 1.0. During periods of normal operation, boilers Nos. 1 and 3 burn about 12 T. of coal during the 8-hr. working day or at the rate of 1.5 T. per hr. This amounts to 20 lb. per sq. ft. of grate surface per hour or about 1.85 lb. per cu. ft. of furnace volume per hour. This ratio is rather large even for normal rating, consequently it is not the practice to carry high overloads because of the appreciable drop in efficiency.

At the present time boilers Nos. 1 and 3 are well able to take care of the one engine being used. When it becomes necessary to run both engines at once the third boiler is put on the line. If, at any time in the future, the steam demand exceeds the permissible boiler output, a fourth boiler may be installed beside the others in a space reserved for that purpose.

Coal is ordinarily purchased from a local coal jobber and is delivered by truck. It is run-of-mine from the Ohio fields and normally runs 30 to 40 per cent volatile and 13,000 to 14,000 B.t.u per lb.

The coal handling system, built by Philips, Lang & Co., as shown in the plan and section of the boiler room, Figs. 2 and 3, operates as follows: Coal is dumped from the truck into a hopper beneath the driveway. From here it is fed by a reciprocating feeder to a two roll crusher from which it drops into a hopper feeding a bucket elevator. At the top of the elevator, the coal is thrown into another hopper feeding a cross screw conveyor which runs the full length of a 400-T. storage bin. This bin is divided into four 100-T. compartments, any one of which may be filled and drawn from as desired. Two spouts opening into each compartment serve to convey the coal to a traveling weighing hopper. After being weighed the hopper is moved along on its track to discharge its load to any one of the three stoker hoppers. From here it falls onto the pusher plate of the stoker and is thus fed onto the grate.

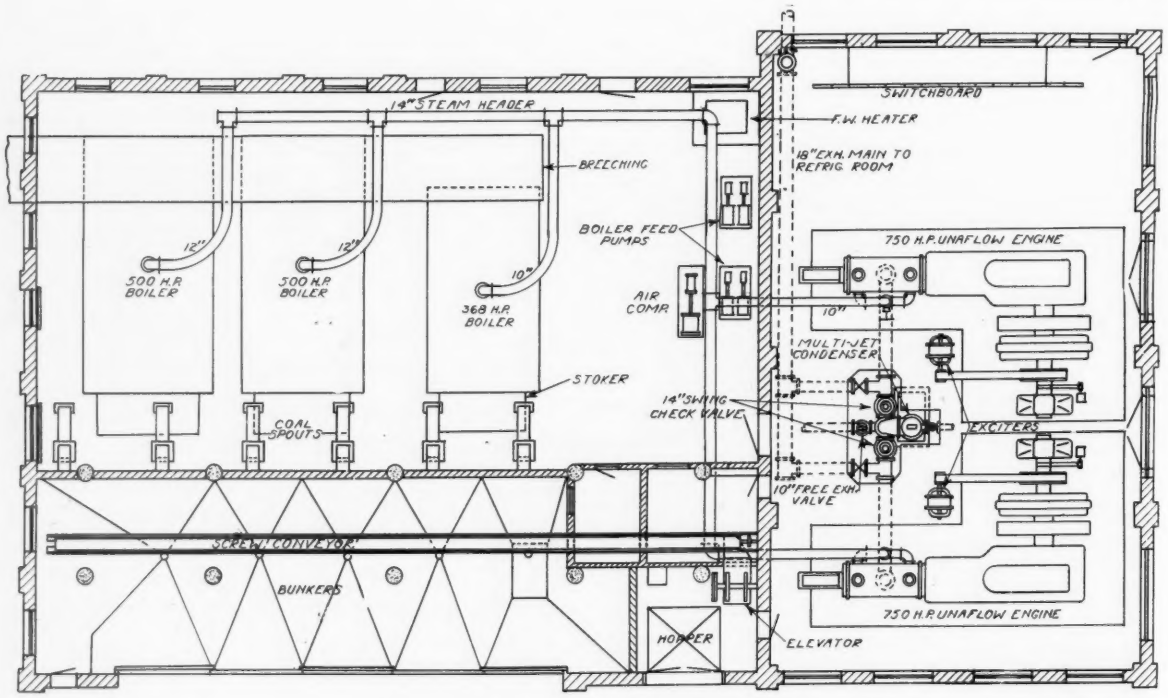


FIG. 2. PLAN OF BOILER AND ENGINE ROOMS

Draft is supplied for combustion by a brick chimney 150 ft. high by 8 ft. 6 in. diameter at the top, located a short distance west of the boiler room.

Ash is deposited by the stoker into an ashpit below the floor level, which communicates directly with a covered pit in front of the boiler.

On the floor of this pit, about 2 ft. in front of the face of the furnace is the intake tunnel of a Brady steam jet ash conveyor.

This conveyor runs along the front of the boilers to a riser about 30 ft. high on the west wall, and thence out to an elevated concrete ash bin west of the boiler room. This ash line is 8 in. in diameter and has two sharp right angle turns. The turns are made in the form of a "T" and are fitted with a plug so that the line may be easily cleared in case of a jam. Originally the line was fitted with two steam nozzles, one at each "T," the one at the bottom being ⅜ in. in diameter and the top one, ½ in. Since then the lower nozzle has been removed as the one ½-in. jet at the top is capable of doing the work satisfactorily with a much smaller consumption of steam. No water spraying equipment is provided and apparently none is needed as there is no objectionable dust.

The ash is raked out from beneath the grates and fed into this conveyor, which deposits it into the covered bin outside. From this bin it is dumped directly into a truck and is carted away, free of charge, by the city, and is used for filling.

All boilers are equipped with Diamond soot blowers which are operated regularly once a day so as to keep the heating surfaces as clean as possible.

One of the three boilers is taken off the line every month and cleaned out with a hydraulic turbine type

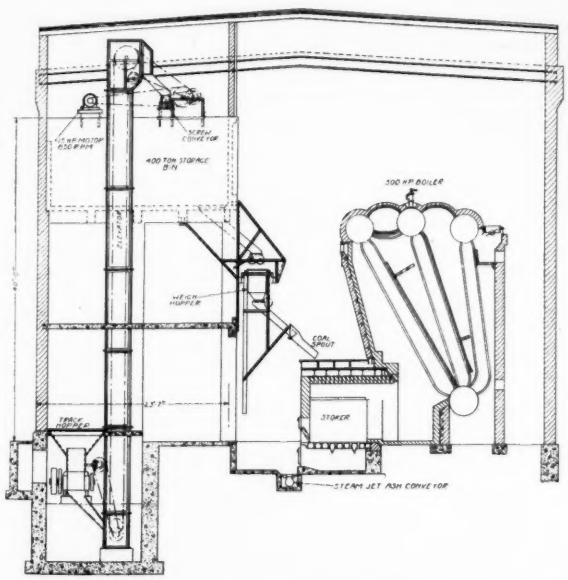


FIG. 3. SECTION OF BOILER ROOM SHOWING COAL HANDLING APPARATUS AND ASH DISPOSAL SYSTEM

tube cleaner so that each boiler is cleaned once every three months. The scale at the end of that time will have accumulated to a thickness of about 1/16 in. at the worst places, i. e., directly over the fire in the first pass where the evaporation is of course the maximum.

The greater part of the exhaust steam is used and condensed directly in process work and is unavailable for boiler feed purposes. That which is used in the heating system and in other closed heaters is returned as condensate to the feed water heater, where it is mixed with the necessary amount of make up and heated to from 210 to 212 deg. F.

The heater is a Stillwell No. 4 open type, rated at 2000 hp., and is located in the suction line to the pumps. These pumps, of which there are two, are the Burnham direct acting simplex outside center packed type; one is 12 by 8 by 12 in. and the other 14 by 9 by 16 in.

The water level in the boilers is maintained at the desired point by a new type S-C feed water regulator. With this control, the feed valve is operated by fluid pressure on a diaphragm. The pressure of this fluid varies with the rise and fall of the water level in what is known as a generator. When the water level is high in the boiler it is high also in the generator just as in any gage column, but due to radiation from the piping connections to the boiler, it is comparatively cool. This cool water tends to cool the generator fluid, thus reducing its pressure. This reduction in pressure on

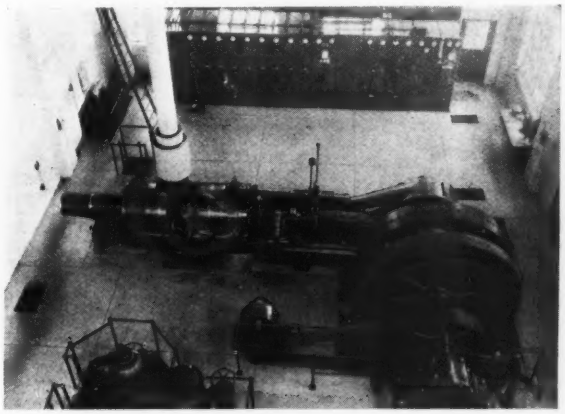


FIG. 4. BIRDSEYE VIEW OF ENGINE ROOM SHOWING ONE ENGINE AND THE CONDENSER

the valve diaphragm allows a spring to close the valve and thus cut off the feed.

When the water is low there is a greater proportion of steam in contact with the generator wall which has the effect of increasing the temperature and pressure of the generator fluid. This increase in pressure acts to distend the feed valve diaphragm and thus to open the valve and allow feed water to enter the boiler.

There is in the boiler room, besides this regular boiler room equipment an 18 by 10 by 12-in. Underwriter fire pump which ordinarily simply floats on the city water line. If for any reason a heavy demand on the city line in the plant causes the pressure to drop below a given point, 70 lb. per sq. in., the pump acts to maintain this head. It is double acting and at full capacity makes 70 strokes per minute, delivering 1000 g.p.m. It is under full steam pressure at all times, but ordinarily does not make more than a dozen strokes a day. Steam is kept on, however, to keep the cylinder warm and to have it available at an instant's notice.

Steam is generated at 150 lb. gage pressure and is taken off through one 10-in. and two 12-in. leads to a 14-in. high pressure header, which runs along the top of the boiler to the east wall and along that to the south wall, where it is dead ended. The two 10-in. engine leads are taken off this north and south run, through the

engine room wall. In the east and west run there is a bleeder connection through a reducing valve to the low pressure line to augment that supply when the engine is running light or when the exhaust steam demand is heavy. Another tap off this line supplies the pumps in the boiler room and the circulating pumps in the engine room basement. All piping and valves, which are of Crane Co. manufacture, are well protected with 2 in. of insulating material applied by Paul Krez & Co. Pipe condensation is thus reduced to a practical minimum.

Engine Room

Power is generated by either one or both of two Skinner Universal unaflow engines, a birdseye view and a cross section of which are shown in Figs. 4 and 5,

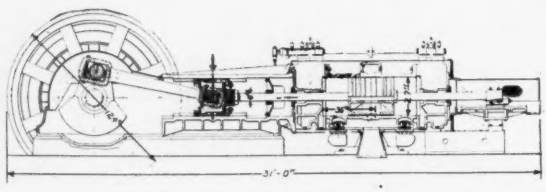


FIG. 5. SECTION OF SKINNER UNAFLOW ENGINE

Each has a bore of 27 in. and a stroke of 36 in. and is rated at 750 b. hp. at 150 r.p.m. The engine is of the bored guide construction and is fitted with a tail rod which supports the massive piston so that only the rings bear on the cylinder wall. The total weight of the reciprocating parts, including the piston, piston rod, crosshead and part of the crank amounts to something in the neighborhood of 4000 lb. In order to keep the speed fluctuation within the allowable limit for generator work a 124 by 20-in., 24,000-lb. flywheel is used.

The cylinder is thoroughly lagged and the heads are steam jacketed, according to the usual unaflow practice. The poppet steam valves are located in the cylinder heads and are operated by an oscillating lay shaft which runs along the top of the cylinder and which is, in turn, actuated through a ball and socket link and bell crank by the eccentric rod.

In common with all unaflow engines, the cylinder expands and contracts longitudinally with variations in load. The heavier the load the greater the expansion and increase in length of the cylinder for the reason that the greater the load the longer the cutoff and consequently the greater the length of the cylinder that is heated by high pressure steam and the higher the average temperature. The cylinder is, of course, fixed at the crank end and as the overhang from that point is about 7 ft. the head end is provided with two shoes that slide on a bed plate and thus support the head, at the same time leaving it free to expand. A flexible exhaust connection relieves the expansion stresses at that point.

The valve gear, not being affected by temperature changes in the cylinder, does not expand with the cylinder, so that there is a relative longitudinal movement between the cams and valves. To compensate for this movement, which would tend to give unequal steam distribution in the two ends of the cylinder, the head end cam rocker is provided with clearance on either side so that as the cylinder moves, a sliding action of the lay shaft is permitted. The lifting gear moving with the cylinder allows the roller to slide across the cam rocker. The result is that equal steam distribution is obtained and the work done in either end of the cylinder is practically the same at all loads as the accompanying indicator cards, Fig. 6, will show.

Each unit is equipped with a Fall's automatic, closed circuit type, engine stop. The actuating mechanism consists of a small, simply designed flyball governor mounted on a horizontal shaft which is belt driven from the crank shaft as shown in Fig. 7. Two belts are used for the sake of safety, so that if one breaks the stop will still function. When the engine overspeeds, the governor spindle moves out and trips a switch which opens the circuit. In this event a counterweighted arm, on a special valve in the steam line, which is held in place by a solenoid, is released and drops. A pin on this arm strikes a lever lock a hammer blow. This action releases the lock on the weighted arm of the valve, allowing it to drop and thus turn the valve through 90 deg. to close it. The solenoid circuit is wired with a switch at the engine room door so that in case of emergency the engine

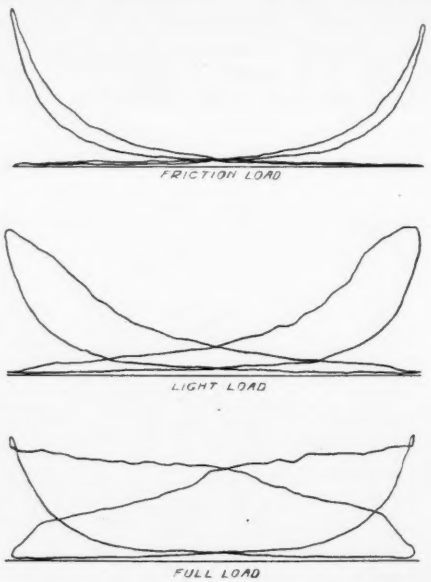


FIG. 6. INDICATOR CARDS TAKEN AT VARIOUS LOADS SHOWING THE EQUALITY OF STEAM DISTRIBUTION IN THE TWO ENDS OF THE CYLINDER

may be stopped from that point by simply opening the circuit. No stop switch was provided on the switchboard for the reason that it was thought that it might be used instead of the throttle valve for normal shutting down of the engine.

These engines normally operate on 140 lb. gage, head pressure and 2 lb. back pressure, but either may be operated condensing should the occasion arise. Operating with 2 lb. back pressure under the full load of 750 b.hp. the economy guarantee on steam consumption is 20.2 lb. per hp.-hr. As a matter of fact, tests show that the water rate does not exceed 20 lb. under these conditions.

As an indication of overall plant economy obtainable both before and after the fire it is of interest to note that the coal consumption has been reduced from 32 to

16 T. a day, while at the same time a 100 percent increase in production has been effected.

This amounts approximately to an increase of 300 per cent in pounds of hides, per ton of coal. It is thought that this ratio will hold for further increase in production.

An unusual and rather trying situation had to be contended with in installing this engine. Unlike most locations where foundations are built on a more or less

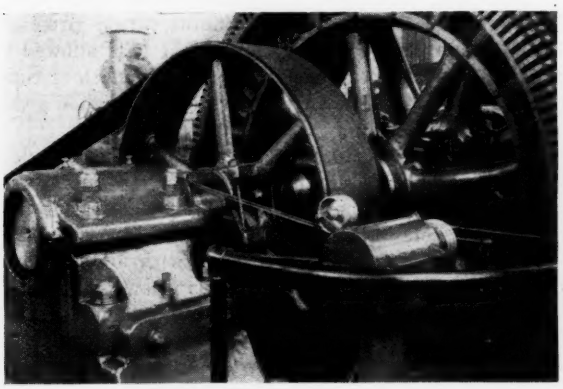


FIG. 7. FALL'S AUTOMATIC ENGINE STOP CONTROL UNIT

firm sub-soil, the foundation for these engines as well as those for the boilers, buildings, stack, etc., had to be laid in a sub-soil of wet, oozy, blue clay, on which the allowable bearing pressure is not much greater than 500 lb. per sq. ft. Although a great number of piles were driven to a depth of some 40 ft., the foundation lacks a great deal of being absolutely immovable.

To be sure the foundation is fairly well fixed in relation to the piling, and the piling in relation to the subsoil, but it is found that the whole underlying clay is unsteady and is subject to quite noticeable vibration

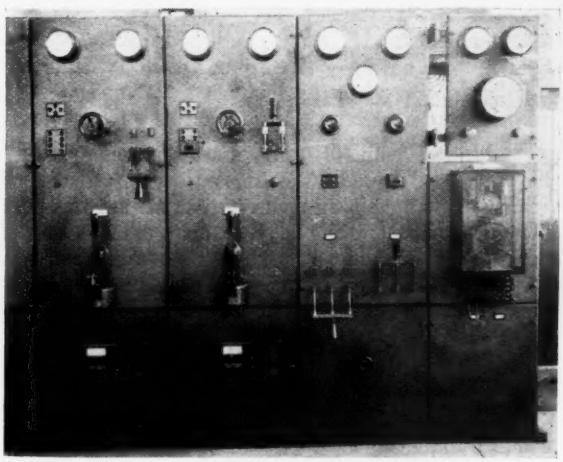


FIG. 8. FRONT VIEW OF THE SWITCHBOARD SHOWING THE GENERATOR PANELS

which peculiarly is scarcely noticeable in the engine room but is quite conspicuous at points as far distant as 1500 ft. in line with the engine. This condition caused considerable concern on the part of the management and steps were taken to eliminate it as far as possible.

For the purpose of minimizing this effect the flywheels of both engines have been counterweighted in an effort to neutralize the inherent shaking forces of the engine. This counterweight is addition to the regular counterweight of the crank cheek and amounts to some 200 lb. on the inside of the rim of the flywheel.

Ordinarily the demand for low pressure steam is sufficient to take all the exhaust from the engine and there are times when it is necessary to bleed live steam direct from the high pressure header. In case of increase of the power load with no accompanying increase of exhaust steam demand, both engines are used and one is operated condensing. This condition frequently

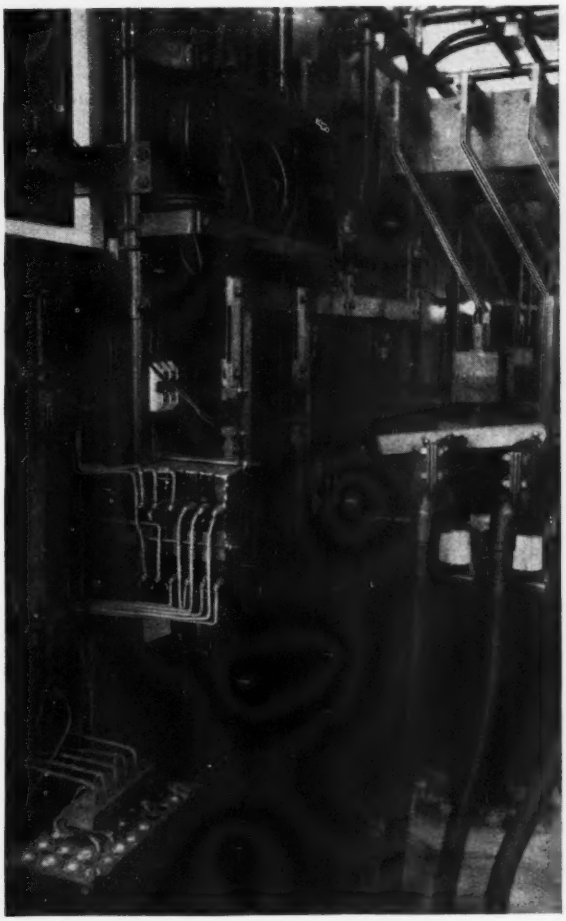


FIG. 9. REAR VIEW OF SWITCHBOARD

exists during the summer months when there is no heating load.

Located between the two engines and connected to both through 14-in. exhaust lines is a Schutte & Koerting multi-jet condenser which is capable of maintaining a 26-in. vacuum on either engine, at full load. Each exhaust line is provided with a gate valve in the line to the exhaust main and a swing check gate valve in the condenser line. Either condensing or noncondensing operation is secured by manipulating these valves. The condenser is provided with a 10-in. free exhaust line which may be opened in case of emergency. Condensing water at not to exceed 80 deg. F. is admitted to the con-

denser chamber through a 7-in. line under a pressure of from 9 to 12 lb. at the rate of about 750 g.p.m. at full capacity. As the steam consumption of the engine amounts to about 14 lb. per hp.-hr., with a 26-in. vacuum there is about 35 lb. of condensing water required per lb. of steam condensed.

Before the occurrence of the fire at this plant, all electrical equipment was operated on a direct current system. When an entirely new system had to be installed, it was decided to employ only alternating current. Now there is not a d. c. motor in the plant, everything is operated on 440-v., 60-cycle current.

Current is generated by two horizontal General Electric 750-kv.a., 440-v., 60-cycle, 3-phase generators, direct connected to the prime movers. The current delivered by these machines at rated capacity is about 901 amp., each, per phase. At the present time only one is being used and that with a load of from 800 to 850 amp. Excitation current for the generator is obtained from a belt driven compound wound generator running at 625 r.p.m., which is rated at 30 kw. and delivers 240 amp. at 125 v. at full load.

Owing to the fact that a large percentage of the load is due to induction motors, the power factor of the system is extremely low, normally ranging from about 65 to 70 per cent, and the actual capacity of the generator is therefore only about 500 kw. In order to increase this factor so as to obtain more economical operation, it has been thought that either a synchronous motor generating set, for furnishing direct current for certain variable speed operations, or a synchronous condenser might profitably be installed.

The switchboard section, of which both front and rear are shown in Figs. 8 and 9, at the north end of the engine room, was built by the Marquette Electrical Engineering Co. It consists of 16 panels. Nine of these mount service switches for various supply circuits, four contain the control switches and instruments such as ammeters, voltmeters, watt hour meter and recorder, power factor meter, frequency meter, synchronoscope, etc., for the two generators and one is equipped for tying in one-half the rated capacity of the plant to an outside source. The other panel has been left blank for a future unit.

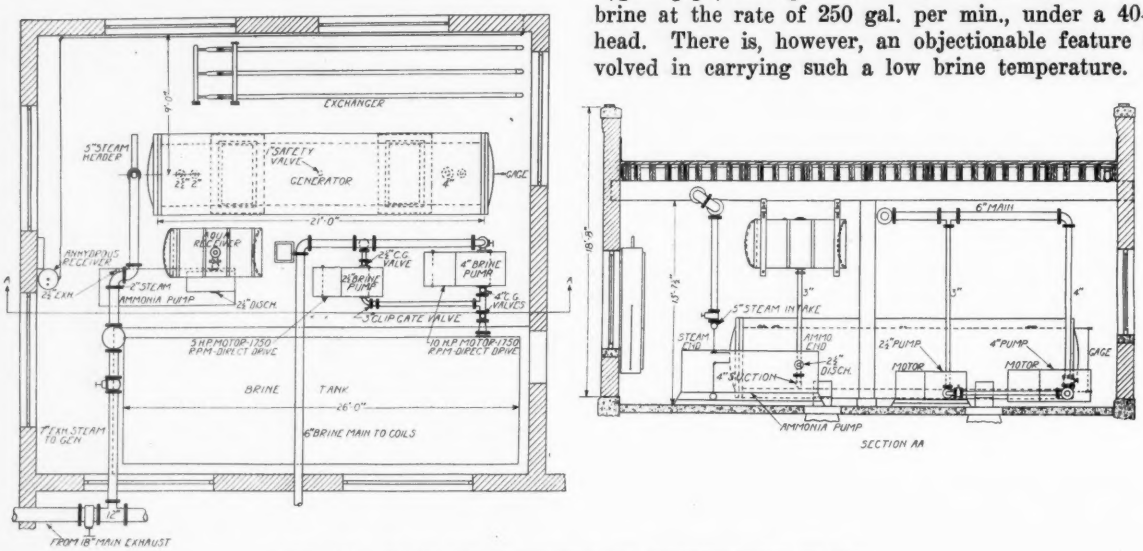


FIG. 10. PLAN AND ELEVATION OF REFRIGERATING PLANT

Refrigeration Plant

An innovation in the leather industry in the method of handling hides is the system recently installed at this plant for cooling the green hides as they are received. It is claimed that the temperatures to which these hides are subjected in transit, which may be in excess of 90 deg. during the hot summer months, often produces objectionable hard spots in the hide, if it is allowed to remain at this temperature for any great length of time. Especially is this true in the case of the higher grade hides such as calfskin.

To reduce to a minimum the hazard thus entailed, the plant has been equipped with a refrigerating system capable of cooling the maximum weight of hides that the plant is able to handle, from 90 to 40 deg. F.

The hide house walls are hung with 16,000 ft. of 1¼-in. pipe, through which there is circulated 18 deg. brine at the rate of 250 gal. per min., under a 40-ft. head. There is, however, an objectionable feature involved in carrying such a low brine temperature. It has a decided dehumidifying effect on the air, which will of course dry out the hides to a certain extent. Arrangements have been made so that in case this effect is too pronounced, brine may be circulated at 30 deg. instead of 18 deg. and at the rate of 400 gal. per min. The brine pumps are of the centrifugal motor driven type. The first is provided with a 5-hp. motor and the second with 10-hp. Both run at 1750 r.p.m.

Refrigeration is effected by means of a 100-T. Carbondale unit, shown in Fig. 10, consisting of a 45-in. by 21-ft. horizontal generator, three-coil double pipe exchanger, two-coil atmospheric rectifier, two-coil weak liquor cooler, 14-coil atmospheric condenser, 14-coil atmospheric absorber, 36 by 72-in. horizontal aqua receiver, 16 by 96-in. anhydrous receiver, 29-in. by 13 ft. 3-in. single pass, shell and tube brine cooler, having 750 sq. ft. of cooling surface, a 9000-gal. brine tank and a 29-ft. by 41 ft. 3 in. horizontal single pass shell and tube water cooler, containing 650 sq. ft. of surface. Anhydrous ammonia is delivered to the brine cooler by means of a 14 by 7 by 16-in. straight line steam pump.

The generator, operating on 2 lb. steam pressure with 60 deg. water requires about 3600 lb. steam per hour with 25 lb. back pressure on the system. Some of this steam, about 750 lb. per hr., is available from the ammonia pump, the rest, about 2850 lb., is taken from the 18-in. engine exhaust main through a 7-in. tap line. Water for condensing purposes is obtainable at about 60 deg. F. The requirements are for about 250 gal. per min.

The refrigerating capacity of the system is much in excess of that actually required were the plant operated on a 24 hr. basis, but the refrigerating unit is operated only 10 hr. of the 24, so that 2.4 times the actual requirements is necessary. During the night the cold brine in the brine tank is circulated through the coils and the cooling effect thus obtained is sufficient to maintain the desired temperature.

On account of shipping conditions the quantity of hides received per day frequently exceeds by several times the daily output of the plant.

As this surplus of input into the hide house must be cooled immediately, the maximum amount of refrigeration required considerably exceeds that required for the normal daily output and calls for a capacity greater than would ordinarily be necessary.

During the summer months, the water supply for process work is not sufficiently cool for best results, so that refrigeration is needed. This water is cooled from 65 to 50 deg., for which refrigeration at the rate of from 30 to 40 T. is required for 6 hr. of the day.

The hide house was not originally constructed to have especially good heat insulating properties; but when it was decided to install this refrigerating system, the roof, where the greater portion of the heat loss occurs, was partially rebuilt. The roof now consists of a layer of 3-in. planking, 5 plies of asphalt paper, above which are the 8-in. joists, the spaces between which are packed with baled hair, and above this again a layer of 2-in. planking and then a covering of 5-ply roofing material.

The total heat loss through radiation is estimated to be equal to about 9 T. of refrigerating capacity.

With this refrigerating plant in operation during the summer months, there will be virtually no change in the exhaust steam demand from winter to summer, so that there will be but little opportunity to operate the engines on a condensing basis. The steam demand will not be reduced, but it is expected that the increased cost of operation will be warranted by the better quality of the product.

Power Plant Auxiliaries

REQUIREMENTS AND TYPES USED IN MODERN PLANTS. BY LOUIS R. LEE

POWER PLANT auxiliaries play an important part in the generation of electric power. The turbo-generator and the steam boiler—the two main units—must be served with many auxiliaries or power using devices.

Not so many years ago, the power plant consisted principally of a direct connected or belted generator driven by a simple or compound engine. In many cases, the engine exhaust went to atmosphere or perhaps to supply some heating system. In such cases about the only auxiliary equipment required in the engine room was the exciter, which in many cases consisted of a small engine set not very different from the main unit. In similar fashion the boiler plant may have been a water-tube boiler equipped with a hand fired furnace using natural draft, the principal and about the only auxiliary being the feed pump. Thus the whole power unit was made up essentially of two main units and two main auxiliaries. This early plant had small capacity and very low thermal efficiency. These plants were simple, generally very reliable and fairly easy to operate.

The progression from this early plant to the present up-to-date plant was rather uniform, although radical improvements have been made at various times in different parts of the plant. The engine unit reached its ultimate development in the cross-compound condensing unit around 5000 kw. capacity. This unit showed many refinements and required and used to advantage condensing equipment similar in design to that used with the modern turbine. Perhaps there was not the incentive then to secure high vacuum that there is now with the turbine unit.

In the boiler plant, the natural draft stoker created a need for a reliable stoker drive. The stoker produced higher boiler ratings and gave value to an economizer. The economizer in turn created a need for an induced draft fan. These early fans were usually the plate type direct connected to moderate speed engines. The turbo-generator or steam turbine and underfeed, or forced draft type of stoker have, therefore, had perhaps most to do with creating the demand for more auxiliaries serving varied purposes.

SERVICES DEMANDING AUXILIARIES

THE DUTIES of the auxiliaries in the modern plant may be conveniently divided into several groups:

(a) Cooling water supply.
(b) Feed water supply.
(c) Air supply for combustion, ventilation and cleaning.
(d) Coal and ash handling.
(e) Plant service.

Cooling water is required for condensing the exhaust from the turbo-generators, cooling power transformers, oil and bearings of turbo-generators, induced draft fan bearings, and washing air for cooling the main generators. The amount of cooling water required may exceed the total quantity of steam used by 50 to 75 times, depending upon the temperature of the cooling water supply, vacuum desired and plant refinements. Cooling water is handled in relatively large quantities and against low heads. In general it is handled by single-stage centrifugal pumps close coupled to small steam turbines or electric motors. The duty is fairly steady and while the service is not severe the continuity of service is very important. Cooling water requires no treatment save in some instances for bearings or transformer cooling coils, and is about as simple an operation

as any in the plant. In most cases, it is necessary to screen the cooling water supply. These screening operations have become quite elaborate and further comment will be made on this matter later.

Feed water supply involves considerable in the way of purification and heating as well as pumping against high heads. In the majority of cases the surface condenser is used and the condensed steam, or condensate, is returned through heaters or economizers to the boilers. Since there must be losses, however, some fresh water, or make-up water must continually be added to the system. Due to the fact that everything, excepting pure water, which is put into the boiler in the feed

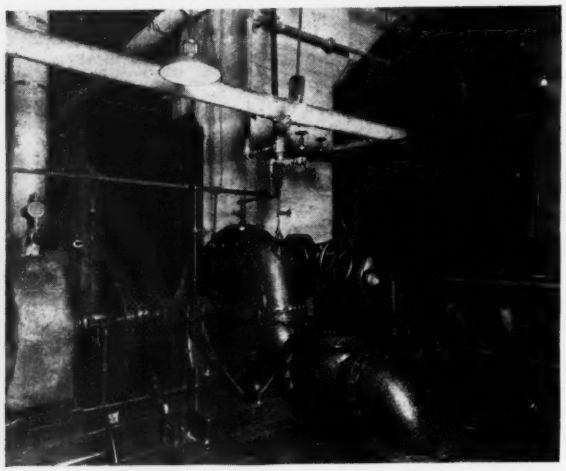


FIG. 1. CONDENSING EQUIPMENT FOR A 15,000-KW. TURBINE UNIT USING A STEAM TURBINE DRIVEN HYDRAULIC VACUUM PUMP

water must stay there, save a small amount which may be blown out of mud-drums, it is extremely important that only pure water is used. The treatment of the make-up water involves the use of auxiliaries chiefly in the form of pumps, where chemical or filter treatment is used and a low pressure boiler or evaporator where distilled water is used. The driving of boilers at high ratings has made the treatment of feed water a very important problem. High fuel prices have emphasized the importance of high plant efficiency, which in turn may be considerably affected by the recovery of waste heat through feed water heating. This is accomplished through two general agencies, the exhaust steam heater and the flue gas heater or economizer.

The air supply is important and may involve the use of more power than any other class of auxiliary. It embraces forced and induced draft for the furnaces, cooling air for the main turbine generators, also compressed air for general cleaning purposes and the driving of boiler, economizer and condenser tube cleaners. The air supply may require cleaning, heating or cooling according to the use that is to be made of the air. Thus, air for cooling the turbine generator must be clean and fairly cool, which is usually accomplished by an air washer. Any heat in the air to furnaces should be a net gain, although the gain due to preheating is not yet very well understood and is not done to any great extent in this country. The air supply involves in general the use of fans direct connected to electric motors or through gears to turbines.

Coal and ash handling involves much in the way of equipment and space, but not so much in actual power. The weight handled is small in comparison with water or air handled. There is not so much opportunity for improvement in power saving as there is in the matter of convenience, reliability and saving in investment and operating costs. Constant speed motors are largely used to drive coal and ash conveying equipment. Variable speed motors, engines or turbines are all used to drive stokers. The chief requisite is reliability under rather difficult conditions and a wide range in speed. The power required per stoker is not large and rather small motors may be used where individual drive is desired. In all cases of stoker drive, as well as coal and ash conveyor drive, enclosed motors have advantages.

Under plant service there are to be found many duties for the auxiliary coming under such heads as excitation, switch control, drinking and lavatory water supply, station lighting and heating. The power requirement is small and the reliability requirement is not high excepting for excitation and switch control, and it is more a matter of convenience and care to see that no unnecessary complication is allowed to creep in.

FEATURES INFLUENCING SELECTION OF AUXILIARIES

THE IMPORTANT features of the whole power plant auxiliary group may be reviewed under the following heads:

(a) Reliability.
(b) Space requirement.
(c) First cost.
(d) Operating cost.
(e) Power requirement characteristics.

Generally speaking all auxiliaries must be reliable; however, there is a wide variation in the importance

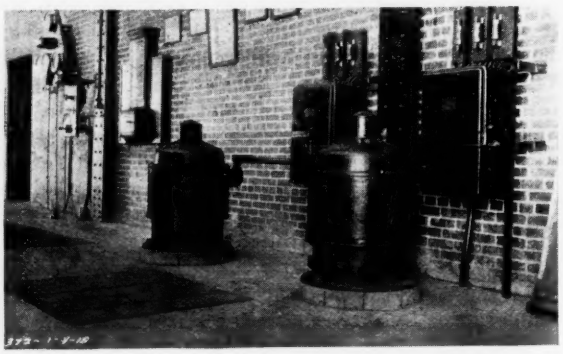


FIG. 2. CONSTANT SPEED 35-HP. VERTICAL INDUCTION MOTORS USED TO DRIVE CONDENSATE PUMPS

of the reliability factor as measured by the continuity of service. Excitation, feed water and cooling water must be supplied by the most reliable equipment obtainable. A failure of such service may cause dropping of load or damage to equipment. Excepting under ideal arrangement it may be difficult to shift automatically from one auxiliary to another in case of trouble with any auxiliary without interruption of the service.

There are three general types of exciters:

1. Direct connected to main turbine shaft.
2. Auxiliary turbine or engine driven.
3. Motor-generator exciter.

Each of these types has distinct advantages for certain conditions. The direct connected to main turbine exciter is an excellent piece of equipment and has the unusual advantage of high reliability and maximum efficiency. The engine or small turbine exciter is a good spare unit to take care of emergencies and the exceptional case. It should only be used in such cases as it is relatively inefficient and expensive to operate. The motor driven exciter is as reliable as its source of power. If it is connected to the main bus through a well designed connection, and the bases properly protected against outside disturbances, then the power supply should be good. The efficiency of the motor generator exciter is less than the direct connected exciter, but it is higher than the engine or turbine driven unit and has a lower investment and operating cost than either the engine or turbine units.

Reliability may be secured in several ways:

1. By proper design and construction of the unit.
2. By duplication of spare units.
3. By proper design and construction of the control.

The auxiliary must have a liberal margin of capacity under the most adverse condition liable to occur. For example: If turbine driven the capacity must be sufficient with low inlet steam pressure and high exhaust steam pressure. If motor driven, the power must be sufficient at low voltage and frequency. In similar fashion, the circulating water pump must be designed to take care of the worst condition considering head and high temperature of circulating water. Allowance must also be made for a reasonable amount of wear where that may in any way affect capacity.

Spare units are a good thing from a reliability standpoint, but cause an increase in investment which is not always justified. A good arrangement of spare units is obtained by using—for example—two circulating water pumps the combined capacity of which is somewhat greater than the total requirements under the most adverse conditions and the capacity of one being sufficient to operate under the best conditions. This arrangement insures against everything except a falling off in efficiency for any short period of adverse conditions with only one pump unit available. The illustration shows an arrangement as described in the foregoing using vertical pumps and variable speed alternating current motors.

Space Requirements

Possibly next in importance to reliability is the question of space required for the auxiliary. In general, the steam driven unit requires more space than the motor driven unit and the horizontal unit more than the vertical unit. The steam driven auxiliary itself may not require more space than the motor driven, but the connecting piping for inlet and exhaust steam requires a great deal more space and generally costs more than the connections for the motor driven unit. There is not always a choice between steam and motor drive. For example: Certain units must be steam driven to allow for starting operations after an interruption, also to provide against the unusual condition. Some capacity in steam driven feed pumps is an absolute necessity. There are also some units which can only be made horizontal; however, circulating water and condensate pumps have been made very successfully in the vertical type, the advantages being obvious in the saving of space, operating convenience and ideal location of both motor and pump.

The development of rotative apparatus has made it possible to make a great space saving over the use of the reciprocating unit. For example: the centrifugal pump requires a great deal less space than the reciprocating pump; also, the turbine requires less space than the engine. The hydraulic vacuum pump is much more compact than the rotative engine driven vacuum pump and the more recent ejector type of vacuum pumps are even more compact and more flexible in arrangement than either of the former types. The high-speed forced and induced draft fans are space savers and at the same time show improvement in efficiency and flexibility.

Saving in space can also be accomplished by a proper arrangement of the different pieces of equipment with

FIG. 3. 100-KW. GEAR CONNECTED STEAM TURBINE EXCITER SET

respect to each other. For example: A unit arrangement usually makes a saving in space due to the reduction in size of piping, flue, air duct connections. The unit arrangement in circulating pumps shows a saving in piping, a reduction in friction head and a generally more compact arrangement. The unit boiler with close connected forced and induced draft fans allow great saving in space usually taken up with air ducts and flue. The direct connected to main turbine exciter is a space saver worth while. The individual drive stoker motor, especially the direct connected motor, is a space saver and gives a simple, compact layout.

Initial and Operating Costs

The first cost is most important in more ways than one. It should always be borne in mind that saving at the expense of quality of material is short sighted and in the end not a real saving; however, any saving in quantity of material by better arrangement, and saving in capacity due to higher efficiency make for real saving in first as well as operating costs.

Unit arrangements give simplicity in design and saving in first cost. It quite often has happened that the cost of installation of auxiliaries has exceeded the cost of the equipment. A careful design may reduce

such costs materially. Operating costs and first costs may be closely related, but it does not follow that high first costs mean low operating costs—it sometimes means quite the opposite. For example: High piping costs may have resulted from the use of too much piping, too many valves, provisions for imaginary emergencies, and so on. In such cases, the maintenance may be high and the heat losses considerable.

Selection and arrangement of the auxiliaries are the essential factors to be considered in making a unit layout. In making the selection, all practical alternatives must be considered and the one chosen should have the greatest number of advantages when installed. Simplicity of arrangement and standardization of connections will go a long way towards low operating costs. The unit arrangement of auxiliaries if properly carried out has the effect of breaking the large plant into smaller plants or units, each one of which is a duplication of the other.

Since the total power required for all auxiliaries may easily reach 10 per cent of the total output, the question of efficiency is important. It is rather difficult to secure a drive with a regulated power supply that

FIG. 4. UNDERFEED STOKER ARRANGEMENT, MOTOR DRIVE BELOW BOILER ROOM FLOOR, ENLARGED STOKER COAL HOPPER SUPPLIED BY A MOTOR DRIVEN TRAVELING COAL LORRY

has a flat efficiency curve. A variable speed direct current motor will come near to meeting this requirement if it doesn't cost too much to provide the direct current power supply. Small steam turbines may also meet this requirement, provided the exhaust steam may always be used to good advantage.

The power demands vary widely in different types of plants and in different seasons of the year. Power plants may be classified according to duty in about four classes:

1. High load factor, fairly constant load.
2. Moderate load factor, fluctuating load.
3. Low load factor, heavy loads for short periods.
4. Very little generation, standby for water power.

In the first two classes, thermal efficiency would be an important consideration and the heat balance would have to be carefully forecast. In the last two classes, capacity and flexibility would be of first consideration and thermal efficiency secondary to cost efficiency as determined by investment, operating costs and labor. For example: A 25,000 kw. plant is required for 70 per cent load factor operation with a moderate daily and seasonal peak load demand. Fuel costs being high in such a plant, thermal efficiency is most important. The turbine units should be supplied with moderately high steam pressure, say 250 lb., 200 deg. superheat; large surface condensers to give maximum vacuum; motor driven circulating and condensate pumps, giving careful consideration to pump efficiency at average full load. Boilers should be installed for moderate—say 200 per cent—continuous overload provided with relatively large economizers.

In the selection of type and dimensions of boiler, special consideration should be given to draft loss under average full load conditions, also special consideration should be given to the arrangement of economizer and boiler with respect to each other, allowing a minimum draft loss under average full load conditions. The draft fans should be motor driven and of the high efficiency type. Feed pumps may be turbine driven, and the exhaust steam from feed pumps, air pumps and feed water evaporators furnishes sufficient preheating of feed water to prevent condensation in economizers. Exciters should be direct connected and power for motor driven auxiliaries taken from main turbines. Such a plant will have a relatively high auxiliary power load, but the auxiliary efficiency will be high, as approximately 90 per cent of the power required will be generated by the main turbines.

As against this, the low load factor or standby plant would be provided with boiler units designed for extreme high ratings, more steam driven auxiliaries, such as draft fans and stoker drive and possibly circulating water pump. The capacity of the auxiliaries would be most important. Chemical treatment of feed water would be substituted for evaporators and larger open type feed water heaters used with possibly less economizer surface, although the higher boiler ratings might justify large economizers, especially with high fuel costs. There is also a possibility of omitting induced draft fans and allowing stack draft and forced draft fans to fix boiler capacity. Where feed water is especially good, jet condensers may often be advisable in the standby plant, allowing a reduction in first and operating costs.

Details of Auxiliary Equipment

Under auxiliary details, there is much that may be reviewed with interest. Centrifugal pumps should be arranged for easy disassembly. The horizontal split casing is usually preferred to the vertical split, although either may be considered a satisfactory unit. Stuffing boxes must be convenient of access and where water seals are required, ample space provided for the sealing water. The deeper the sealing water over the gland the better. Condensate may be used to good advantage for sealing where an extreme effort is being made to get best feed water conditions. Metallic packing is very satisfactory if care is taken to get a good fit at starting. Thrust bearings of large size of plain type, or properly designed ball thrust bearings, are very satisfactory, the ball bearings usually requiring less attention for lubrication.

Flexible couplings are important and advantageous on most rotative equipment. This is especially true of large vertical circulating pumps and also for motor driven draft fans. There are many types of flexible couplings, but the more simple types using solid steel flanges, with fibre or rubber inserts, give good satisfaction. Direct connection of motors, turbines or engines is preferable to belting, gear or chain driving; however, speed reduction is often necessary and in such cases the amount of speed reduction and the nature of the work will have considerable to do with the selection of the reducing medium. Gears are compact and will admit of maximum reduction, but if used for great reduction and continuous service may become noisy and unsatisfactory. A silent chain drive is most satisfactory under proper conditions, such as moderate speed, where enclosed and where off setting of driver is no disadvantage or is a positive advantage. Belts are used successfully on air compressors and economizer scrapers, or where intermittent or light service is required.

Variable speed is important in a number of cases and may be obtained in many ways. Some stokers are provided with mechanical means for changing speeds. A steam driven unit lends itself to efficient speed regulation within rather wide limits. Direct current motors are easily adapted to speed regulation and may be operated efficiently over a wide range. The principal and only real objection to the use of direct connected motors is the matter of direct current generation. A motor generator or synchronous converter may be used to supply direct current, but such an agency places one more piece of equipment between the source of supply—the main turbine—and the auxiliary drive. There is also some loss in this secondary generating device; however, the increased efficiency of the direct current motor at regulated speeds will probably offset the motor generator losses. There are some auxiliaries, such as stoker drive, where direct current motor drive is most desirable.

The speed of induced draft fans may be varied to good advantage, but forced draft fans can be secured with nearly a flat power curve. It is, therefore, quite satisfactory to drive forced draft fans with constant speed motors and regulate forced draft pressure by hand operated damper.

Feed pumps may well be driven by constant speed motors, provided sufficient steam driven pumps are kept in readiness to operate, the discharge being regulated with suitable pressure reducing valve.

Circulating water pumps may be advantageously driven by variable speed motors, due to variation of water elevations and temperature, which affects the quantity of water required.

Condensate pumps may well be driven by constant speed motors. Cranes should be provided with direct connected motors. Direct current is also necessary for switch control and switchboard signals and for this service it is important to have storage battery to insure constant supply and steady voltage. The switch control service should be isolated from all other auxiliary service. This also applies to main turbine generator excitation. In some cases, it has been thought advisable to provide a fairly large storage battery for switch control suitably arranged for emergency excitation. It is well to arrange some emergency lighting from storage battery supply.

House water, battery charging sets, pumps, etc., may all be driven by constant speed motors.

In conclusion, the success of the auxiliary must depend upon the proper selection as to capacity, type of drive, point of maximum efficiency, control and assembly. There is a proper place for both the steam driven and motor auxiliary, but the reason for selecting one or the other depends upon the nature of the service, demands upon the plant and the limitation of first and operating costs. The details of the auxiliary are most important with reference to speed, speed control, method of connecting driver and simplicity of assembly. Generally the constant speed motor is most desirable for steady operation at fairly constant load.

Variable speed, within certain limits, may be satisfactorily obtained from alternating current motors, but consideration must be given to the advantages of direct current motors for many places, such as stoker drive, where wide variation of speed is most important. The auxiliary turbine is to be preferred over the engine driven and has a place in every plant, but it should be used only where the motor is unable to meet every requirement.

A uniform arrangement of standardized sizes will do much to make the power plant auxiliary reliable and economical. The term "economy" must cover all, including first cost, depreciation and maintenance.

In Case of Fire

By J. B. Dillon

IT IS said: "Whom the gods would destroy they first make mad," and all of us know that when we are angry or over-excited we cannot reason as we do when we are normal.

Certain it is that if our factory is afire and there are lives in danger we will be unduly excited; but if we have studied "what-to-do" in case of fire, we have a better chance to put into practice helpful ways and means than to think out a course of procedure while unduly perturbed.

Always sound the alarm calling for the fire department and see that a stream of water from your auxiliary system is played between the place of egress and the fire, the purpose being to hold the fire back as much as possible.

There are cases where a ladder placed here or there will accomplish the desideratum; but it too often happens that the ladders, except the fire escape proper, are too short.

You have often heard that fires spread rapidly; that they seek an elevator shaft or a stairway. This is correct, the hot gases rising and the flames, being "hot gases," wish to rise. Now, if there is no stairway or elevator shaft connected with the room where the fire started and there is danger of it spreading over the entire house because of the inflammable objects around, cut a hole in the floor above, if possible, thus creating a flue and confining the fire to that particular part of the building.

Local conditions will suggest to you where the various vulnerable spots are and then you can liken the things—in advance—to a chess board and figure out your "moves."

Economics of Water-Power Development*

Discussion of Production, Maintenance and Selling Costs and Fixed Charges. By Curtis A. Mees

ECONOMICS, as applied to this particular subject, relates to the planning and administration of hydroelectric plants in a manner such as to avoid wastefulness and extravagance.

The question of water-power development as a paying proposition, however, is another matter, and since each of these concepts covers a very wide field, it seems preferable at this time to touch, in a very general way only, on the essential factors pertaining to both problems in such a manner as to elicit profitable discussion thereon.

Only in very rare instances is it practicable to depend on water alone for the production of power for commercial purposes, and auxiliary power sources are therefore presumed to be a necessity and their construction and operation is herein considered as concomitant to water-power development.

The power business is akin to that of manufacture, as this term is usually conceived, and the conduct of this business is in many respects successful or unsuccessful in that measure in which the precepts for efficient and profitable manufacture are observed.

In other respects special problems are presented because the product after manufacture must be sold and delivered to the consumer, for instantaneous use in a circumscribed market; and while the selling cost is dependent entirely on the immediate operation of the law of supply and demand, the selling price is generally fixed by regulation.

Just as this is true of any manufacturing enterprise, the success of a power development depends not alone on the perfection of the Physical Structure, i. e., the mechanical equipment, and the Production Structure represented by the operating personnel, but in even greater measure on the efficient functioning of the Commercial Structure and the adequacy and flexibility of the Financial Structure. Many monumental developments are, by the well informed, known to be failures.

It should be readily appreciated, therefore, that in any abstract discussion such as this it is impracticable to attempt anything beyond merely setting forth various items that particularly require consideration in an analysis of the commercial features of a power development, and pointing out in general terms their effect on net earnings, or the margin between selling cost and selling price.

Factors of Selling Costs

Selling cost is made up of raw-material cost, fabrication cost and delivery cost. In each of these costs we have both variable elements subject to fluctuation with quantity production and susceptible to modification, and fixed elements which are not affected by applied economics, once the physical structure has been completed.

To each of these classified accounts there must of course be disbursed, either directly or in proper proportions, managerial supervision, clerical expense, cost of tests and experimental research, and a multiplicity of similar charges which occur in all manufacturing business and involve no peculiar features.

The raw-material cost may be determined by any or all of the following items: rental of water; land and water rights for reservoir; conditioning of reservoir; hydraulic control works; fuel delivered to plant; fuel-handling and storage facilities.

In establishing the feasibility of a development in view of these items, it should be noted that the unit cost of fuel is indeterminate unless quality is fixed by specification. Loss or deterioration in storage is variable applying equally to fuel or water in a reservoir, and for water as well as fuel the the unit cost is indeterminate unless quality and quantity are fixed by specification.

The cost of structures such as dams, gates, pipe lines, coal crushers, oil tanks, etc., determines fixed charges for water or fuel. Operation and maintenance of these structures are variables, and in planning them the engineer may choose whether fixed charges or the variables shall be increased or decreased.

Fabrication Cost

Of the three cost elements, fabrication is least affected by fortuitous circumstances. In a broad sense this cost is made up of fixed charges growing out of the capital cost of erected power-generating equipment, suitably provided with necessary or desirable adjuncts, housed or located outdoors as the case might be, and of operating charges which include wages, supplies, repair parts, etc. Capital cost of the plant may, however, and quite properly so, lie between wide limits for the same output of product, depending on two totally distinct provisions: uniformity of steam flow and character of service requirements, both as to continuity and uniformity.

It must be borne in mind that the manufactured product is kilowatt-hours, that the time element is just as important as the capacity element and that, in general, a sale is consummated only when capacity is available at the instant of use and for the period of use. Thus the hours of use for any given market must be most carefully predetermined for the power selection of prime movers, and beyond this capacity must also be provided equivalent to the maximum instantaneous demand for current, else the product will not be salable.

Capacity for the water-power plant having been fixed by the character of the load, there follows the determination of proper capacity for the auxiliary plant.

While this choice may possibly be dependent on a volume of output imperatively continuous, it is much more likely that it will hinge on meteorological criteria.

Natural stream flow is determined either by measured discharge or by computed run-off based on recorded rainfall. From these data there is estimated the average annual stream flow and these determinations will approach correct values according to the length of the period of observations considered. These findings should be modified by an accuracy factor.

*Abstract of paper presented at the spring meeting, Atlanta, Ga., May 8 to 11, 1922, of The American Society of Mechanical Engineers.

Depending on the topography of the development site, either at the power plant or on the drainage area above it, storage capacity may be created of such extent as to afford either daily or seasonal regulation,

For high-water stages, while there will be an excess of water available, it frequently happens that loss of head results from this cause and in that event restriction of output must be determined similarly as for low-water stages.

Only in exceptional cases is it commercially practicable to develop a water-power plant for an output based on absolute minimum stream flow, and it is therefore customary to base earnings on that output which may be produced in the average year.

The equipment of the auxiliary plant is then primarily fixed by that capacity which may be necessary to supplement the water output of the lowest year to bring it up to that of the average year. Beyond this, except for possible emergency capacity, it becomes a question of dollars and cents, based on salability of secondary power and rates which may be secured for this service, as to the extent to which one can afford to install auxiliary equipment for the conversion of short-term water output into continuous combined water and auxiliary output.

Dependent on local conditions, the capacity which must be installed for emergency service might finally be the determining factor in equipment selection. It may happen that in flood a water-power plant may be completely incapacitated through loss of head, so great as to make impossible the maintenance of synchronous speed. Ice blocks also might completely prevent operation of a plant. For such cases, under certain load conditions, it might become imperative to provide 100 per cent standby capacity.

Delivery Cost

Delivery of power may be effected either direct to the ultimate consumer or at wholesale to a distributor and the cost of delivery depends very largely on the method in vogue or proposed, but the greater cost of retail service is offset by a rate differential such that in the end earnings on the unit of investment are not, in general, materially affected by the adoption of one rather than the other of these plans.

A transmission system may be considered to be composed of trunk lines, secondary lines and feeders. The cost of trunk lines depends primarily on the proximity of the power plants, principal and auxiliary, to each other and to the center of the load, whereas the cost of secondary lines and feeders depends largely on quantity requirements, both as to capacity and period of use, or what is synonymous, the number of consumers served and the density of the market.

Secondarily the cost of transmission lines is affected by the relative importance of assured continuity of service and in addition the locality variable enters into the problem. Urban work, values of land, size of properties crossed and similar circumstances greatly affect the cost of lines. The rigors of climate, cyclones and the prevalence of electrical disturbance require careful consideration and arbitrary regulations as to structural details must frequently be observed, whether the cost is justified or not.

Factors of Selling Price

Selling price depends on either the cost of a competitive product or rates fixed by a regulatory body; i. e., in the last analysis, by the purchaser.

The competitive product may be either purchased electrical power or produced power. Regarding the practicability of competition with purchased power, there can of course be no controversy. The feasibility, however, of building a water-power plant or system for the competitive sale of electricity with that otherwise produced is not always so readily established. The selling cost of high load factor power, produced in large volumes with fuel at reasonable cost, is not, in general, appreciably higher than that produced by water, if in the latter case the transmission cost amounts to much.

In small fuel plants, however, and particularly when operating at a low load factor, it is at the present time impossible to produce power at a cost as low as that at which reasonably near and economically developed water power can be delivered.

Effect of Regulation

To regulation we owe general recognition as public utilities and as such we are granted eminent domain for transmission-line rights of way, and sometimes for water rights. This means that we cannot be arbitrarily stopped from proceeding with certain plans of development and that we do not have to pay such a very great deal more for property rights and easements than the market value thereof.

The impression prevails that, under regulation, the income of a utility is guaranteed. This is an utter fallacy. The income is merely limited, and in too many cases unfairly limited. Within the last few years earnings on securities have in too many instances had to be paid out of funds which should properly have been devoted to maintenance, or possibly unwise curtailments have had to be made in personnel. Deferred maintenance is the most serious disease with which a utility may be afflicted.

Composition of Financial Structure

The financial structure which supports this industry is, in general, composed of:

A Lender: To whom payment of interest is compulsory under the security which he holds and which amounts to the entire property owned.

The lender sees to it that this is a safe risk. His criterion generally is that estimated net earnings shall be at least two times and generally two and one-half times the bond interest.

A Preferred Investor: In stock whose payment in dividends is substantially guaranteed under a lien subordinate only to the bondholders' equity. This investment is attended with all sorts of management and non-insurable structural risks.

A Speculative Investor: In common stock whose dividends are paid only if there is anything left over.

It is of course obvious that holders of junior securities are entitled to returns greater than those of the lender. The cost of money for work of this kind, when intended for new and untried uses as it generally is, must yield a return fixed by experience for semi-speculative investment. Customary and proper rates of return under respective security holdings may be set

up as follows, based on the existing actual, not legal, interest rate for short-term collateral loans of equal volume:

	Per Cent				
Actual interest rate.....	4	5	6	7	8
Bond interest	5	6	7	8	9
Preferred stock dividend....	7	8	9	10	11
Common stock dividend.....	10	11½	13	14½	16

Unrecoverable Losses

Based on the law that utilities should not make unjust profits, it should equitably follow that they are entitled to protection against unjust losses. In financing such undertakings reliance is placed on constancy of return and rates are predicated on probable normal output. Industrial activity, however, varies in cycles and a falling off of normal business cuts into earnings in a manner which cannot be guarded against because, in general, equipment capacity kept in readiness to serve under contract provisions cannot be otherwise put to work. Contract minima, ordinarily, assure nothing more than the earning of bond interest alone.

Losses of output and therefore earnings are sometimes seriously affected by storm or flood conditions, against which the property cannot be guarded. Fire and breakdowns may, without fault on the part of the operating personnel, render normal service impossible and emergency service under any of these conditions is apt to be very expensive, but nevertheless practically obligatory. Interference with business by strikes, declaration of martial law, etc., mean unavoidable loss of income.

Against none of these contingencies can the management protect itself as this is customarily done and essential to safe business conduct, i.e., by the setting aside of a contingency or, as it has been called, a "stabilization," fund.

Rates for electrical current are presumably based on cost of the service, painstakingly predetermined for each particular case. Cost of service is, however, susceptible to considerate modification depending on the degree of efficiency attained in administration of the property. If earnings are absolutely limited, the incentive to efficiency is lost and that is one of the most discouraging features of rate regulations. Zealous communism is only a theory.

Having in broad terms indicated some of the more vexing problems that confront the industry, an attempt will now be made to present as concisely as possible a schedule of economic considerations, the observance of which may lead to more satisfactory solution of these problems.

As to the Physical Structure

Design and Construction of Plant:

1. Thorough Preliminary Study: Geologically, meteorologically, legally and commercially. Such study requires time and money and both are too often curtailed.

2. Control of Entire Stream: To make regulation most effective and to prevent competitive injury.

3. Degree of Stream-Flow Utilization: The extent to which secondary power may be developed for sale or conversion into primary power.

4. Best Use of Land or Water Rights: Mechanical or automatic pond-level control to maintain a maximum head.

5. Plan of Development or General Layout: Location, utilization of site (extent, method), progressive construction and stream regulation, location of auxiliaries, territorial control of market.

6. Type of Structures or Detail Layout: Kinds of dams, character of water channels, equipment setting, equipment housing, effective design for tail race, use of adjunct equipment, and belt-transmission trunk lines.

7. Type of Equipment: Prime movers suitable for characteristic load and service. Effective accessories. Adequate recording instruments, high-efficiency draft tubes and use of ejectors or tail-water elevation control Air coolers for generators. High-potential generation or transmission. Automatic or semi-automatic generating stations and substations.

Selection of Auxiliary Equipment. Ordinarily this should be high-capacity, quick-response, equipment of low first cost. Dependability is much more important than economy of operation, although low attendance costs are to be attained if possible. For this purpose there are best adapted steam turbines and boilers equipped with mechanically atomizing oil burners or powdered-coal-burning equipment. Heat balance is of secondary importance. Electrically operated auxiliaries are better for quick starting.

8. Capacity of Equipment, Unit and Total: Adaptability for characteristic load changes. Maintenance of balance, large and small units. Amplitude of reserve capacity. The cost of prime movers alone is generally only a small proportion of the total development cost and sufficient spare capacity should be installed.

9. Economical Construction: Effective building organization, executive, clerical, supervisory. Conscientious inspection. Economical purchasing. Reduction of unproductive construction period to the economical minimum. Assurance of service continuity by careful testing out.

10. Interconnection between power systems.

As to the Production Structure

Operation of Plant—Production and Distribution: Routine:

1. Regular inspection and tests; owner's installation and customer's installation.

2. Effective service records and accounting.

3. Proper use, maintenance and loading of equipment.

4. Maintenance of balance between water and auxiliary power. Assuming storage to exist, it is generally best when an auxiliary plant requires operation, to operate it at full load, taking peaks on the water-power plant.

5. Fuel-efficiency control. Volume purchase by combined interests on specification basis under strict supervision.

6. Perfect load dispatching based on meterological observations.

Administrative:

1. Proper selection of employes.

2. Education and training of employes—general, specific. Explicit written instructions should be furnished each employe setting forth his duties, methods of accomplishment and reasons for performance. Maintenance of discipline.

3. Development of loyalty and co-operation in em-

ployes. This may be brought about by fair dealing, manifest integrity of purpose, welfare work, encouragement by public recognition of especially meritorious service, appreciative adoption of suggestions and partnership in the business which should be made easy.

4. Acquirement of expert detail knowledge of the business in a manner to make information instantly available for effective analysis and synthesis.

5. Research and investigation to perfect methods which information should be co-operatively interchanged.

As to the Commercial Structure

Selling the Service:

1. Perfection of service.

2. Saturation of system; development of rural loads.

3. Selection of load: While the service requirements in a given market are quite characteristic, some improvement is generally possible. The diversity factor may be improved, the maximum demand may be cut down and the load factor may be raised by the encouragement of off-peak loading. Electrolytic processes, electrical industrial heating, domestic use of heat in all manner of appliances, and off-peak pumping and similar intermittent service suggest themselves as desirable loads.

4. Protective contract provisions: Service classifications, unavoidable interruptions of service not to be penalized, maximum demand limitations, power-factor penalties and bonus, fuel clauses, agreement to pass along extraordinary taxes, cost-of-living adjustment.

5. Classified service accounting to detect inadequacy of certain rates.

6. Development of a sympathetic, understanding attitude in consumer by intelligent publicity and helpful advice as to proper use of current and equipment.

7. Avoidance of too preponderant a load from either one or just a few consumers or either or several closely allied industries.

As to the Financial Structure

Providing Funds:

1. Balance in equities of classified security holders.

2. Adequate working capital provisions.

3. Bond issue under a series mortgage.

4. Consumer partnership.

5. Reinvestment of depreciation reserve.

In all of the foregoing it must be remembered that small plants require different treatment from that accorded to big plants and that isolated plants must be quite differently planned from those forming part of a chain or system.

Cost Accounting System for Small Utilities---II

Subdividing Expenses. A Start on the Cost Sheets. By Mac Hanson

IN ORDER that you may understand the problem that the town was undertaking to solve, I will set down the facts of the situation as they then existed.

The Town of Kineford had built its electric and water plant, which was commonly called the "light and water plant," in 1903. The plant cost $32,500, and the town had no funds available to meet the expense. The state law allowed a municipality to issue its bonds not in excess of 2 per cent of its assessed valuation, so the town board issued bonds in amount of $8500 and mortgaged the plant for $24,000 additional, issuing mortgage bonds. Both "town bonds" and "water bonds," as they were called, drew 5 per cent interest.

The town board hired a "Superintendent" to manage and operate the entire plant, his salary, at the time of this writing, being $330 a month. The superintendent hired his own labor to operate the plant, extra labor, for line repairs, renewals and extensions, etc., both on the electric line and the water line, being paid for by the town board as this expense was incurred. The board, of course, paid for all materials and overhead expenses of running the plant.

The day marshal was made collector of service accounts and received $5 a month for this service. After the cost accounting system was installed, which system we will shortly explain, the keeping of this system was made a part of the town clerk's duties and he was allowed $75 a year for this service. These were the only labor and service expenses charged against the plant, viz., superintendent's salary, extra labor, collector's salary and accountant's (clerk's) salary. Of course, any special services such as boiler inspection were charged to the plant and paid for by the board out of the light and water fund, but such services were usually classed under the "extra labor" heading.

All electric service was measured by the customers' meters; there was not a single flat rate customer of record. All water service was flat rate service; there was not a single metered customer. Water service was payable in advance quarterly. Electric service was paid on bills rendered bi-monthly. It was the duty of the superintendent to read the meters. He read the meters in the south half of town, one month, and in the north half of town next month. The only exception to this program was the business houses whose meters were read every month.

The electric rate for commercial service was 15 cents a kilowatt-hour, straight. For power service it was graduated—12 cents for the first 100 kw.-hr., 10 cents for the second 100 and 8 cents for all over 200 kw.-hr. per month. The minimum charge on all electric service was $1 a month.

The water rate for residential use was $10 a year minimum, for one house faucet and one yard hydrant, and $15 a year minimum where bath and toilet, either or both, was in use. Extra service or openings were charged extra and business houses had special rates according to the use made.

The central station that housed both the electric and water utilities machinery was located along a railroad siding. The boiler room furnished steam for both utilities. The electric utility had a Corliss steam engine direct-connected to d.c. generator and a.c. rotor. It also had another older type steam driven outfit. The water utility used a steam driven "deep-well pump" to lift water from the main well, 180 ft. deep, to the reservoir, and steam-driven force pumps to keep the pressure on the mains. Steam was also used to operate the boiler feed water pumps and the water heater.

There was one master electric meter on the instru-

ment board which had been installed in January, 1920. All current for commercial and power use and for street lighting passed through this master meter. Each customer owned a meter used at his place of business or residence. The town board, through its superintendent, purchased these meters and sold them to the customers at cost. The plant had no water meter, steam flow meter or any other measuring device of any kind.

The superintendent was in reality a business manager. He hired or fired his help; maintained and operated the utilities; purchased, stored and used materials; managed every part of the business except collecting and rate making; but was theoretically under the town board's direction and was supposed to consult with the board's light and water committee before adopting or

accountants agree that cost finding should be done by departments, not for the business as a whole. This gives two desirable results. First, the cost for each department is thus known and excessive costs can be localized. Second, ways and means of reducing costs can be more easily discovered. These are the two principal reasons for and advantages gained by a system of cost finding—to know what the costs are and then to know how to reduce them, or at least keep them within due bounds; and the latter is more important by far than the former.

The largest items of operating expense were fuel and labor. The plant used 1500 to 1600 T. of coal annually. Tom decided that a coal record should be kept as the first step. The town purchased coal in car-

1922 — CAR LOAD RECEIPTS

MONTH REC'D	FIRM	DATE ORDERED	DATE REC'D	DATE PAID	CAR INITIAL	CAR NUMBER	KIND OF COAL	WEIGHT IN LB.	PRICE PER TON F.O.B. MINES	INVOICE	FREIGHT RATE PER TON	FREIGHT	WAGE RATE PER TON	LABOR UNLOADING	TOTAL COST	EXTRA EXPENSE	GRAND TOTAL COST
JAN.	[illegible]	12/23	1/1	1/25	N.Y.C.	315 629	Egypt	53 000	2.75	114 13	1.66½	64 18	.25	16 25	195 61		
JAN.	" " "	12/27	1/3	1/25	J J	4 534	"	62 600	2.75	86 63	1.66½	52 11	.25	7 83	146 62		
JAN.	" " "	12/29	1/6	1/25	C.T.C.J.	11 377	"	107 300	2.75	147. 54	1.61	86 38	.20	10 73	244 65		584 .28
FEB.																	
FEB.																	
FEB.																	
MAR.																	
MAR.																	
MAR.																	

1922 — WAGON LOAD RECEIPTS

MONTH REC'D	FIRM	DATE ORDERED	DATE REC'D	DATE PAID	KIND OF COAL	WEIGHT IN LB.	PRICE PER TON AT COAL YARD	INVOICE	TEAMING RATE PER TON	HAULAGE		EXTRA EXPENSE		GRAND TOTAL COST			
JAN.																	
JAN.																	
JAN.																	
FEB.																	
FEB.																	
FEB.																	
MAR.																	
MAR.																	
MAR.																	

FIG. 1. COAL COST SHEET OF KINEFORD ELECTRIC & WATER UTILITIES. DESIGNED BY "MAC HANSON." RIGHT TO REPRODUCE AND USE FREELY OFFERED TO ANYBODY

pursuing any change of policy or management, and, especially, before incurring any extraordinary expense.

When the superintendent finished his meter readings, he turned these over to the town treasurer who figured out the accounts payable and kept each individual customer's record of accounts payable and settlements received. The treasurer made out the statements of account and turned these over to the day marshal for collection.

The superintendent in charge Jan. 1, 1921, had made an inventory of materials and supplies on hand, and of plant equipment on that date, which was the first inventory that had been made for years. Bob Johnston had been appointed superintendent April 15, 1921, when the board had reduced the superintendent's salary from $400 a month to $330 a month and the former superintendent had immediately resigned. This was the status of affairs when Tom started working out a cost finding system.

Tom had only one premise as a starting point. The cost finding must be done by "departments" in order that the annual totals by departments could be drawn directly from the cost sheets to fill in the report blanks sent out by the Public Service Commission. Most load lots direct from the broker, and also, when necessary because of low stocks on hand, bought some from local dealers. The coal record form is self-explanatory and cut of it is here shown to indicate its make-up and the items listed. Its mechanical make-up was as follows:

Tom took a sheet of legal cap paper and opened it out lengthwise. With yard stick and pencil he ruled this sheet lengthwise (between the two marginal rulings printed thereon), with lines 3/16 in. apart. He then ruled the entire sheet crosswise into columns each two lines wide. Above the heavy printed marginal ruling he entered the column headings as shown. The left-hand half of the sheet contained the car load receipts and the right hand half contained the wagon load receipts. This form was large enough to hold a year's record for Kineford's plant. If your plant uses more coal than this, the form can either be made wider by pasting on another sheet of legal cap paper at the bottom, or, preferably, by using one sheet for six months. The columnar headings of this "Coal Cost Sheet" are self-explanatory.

The item "extra expense" took care of such expenses as re-handling coal when stocking in large amounts. The grand total cost was entered monthly, and each

column requiring it was totaled annually, or oftener if desired. The wagon load receipts were recorded similarly, though with less number and slightly different headings. Should your plant require more headings, such as scale weights, surplus or shortage in mine weights, name of mine, location of mine, vein of coal, trade name of coal, degradation loss by weight, degradation loss by monetary value, demurrage, etc., then the columnar rulings can be made narrower in order to get the necessary number of columns required, or more legal cap paper can be pasted on at each end of the sheet to provide the necessary space.

After Tom had made his rough draft of this form, the actual ruling of it and entering of headings required much less than an hour's time, and it was suitable for a year's record. Tom wrote the name of the form and the year across the top of the sheet and also on the outside front of the sheet. He then folded it back on itself as it originally was, and then folded it twice more endwise, which made it just right to file in a standard sized 4⅛ by 9½-in. envelope. Across the face of the envelope he wrote "L. & W. plant cost sheets, 1921," and filed all his forms in this one envelope.

After further study, Tom found he would have to run a cost sheet on the boiler room separately, because steam for both electric and water utilities was generated in one boiler and piped to both the "electric utility power plant," i.e., to the Corliss engine, and to the "water utility power plant," i.e., to the deep-well pump and the force pumps. And there were no steam flow meters. Therefore the expense of steam to each utility would have to be "apportioned," that is, estimated, or shrewdly guessed at; and in order to make a guess, the total cost of steam must first be known.

So he started to work out a "steam generation apportionment" cost sheet. The first item he set down as "labor." But the only item of regular labor that the town board recognized was the superintendent's salary. Of course steam generation didn't get all of this. It must be spread out over the various departments on some basis. Besides, the Commission's reports asked for "superintendence" and "operating labor." So Tom consulted his brother, Bob, the superintendent, about distributing this item. Bob hired two men regularly at the plant. The day man worked from 11:00 a.m. to 9:00 p.m. and received $105 a month. The night man worked from 9:00 p.m. to 7:00 a.m. and received $95 a month. Bob, himself, worked from 7:00 a.m. to 11:00 a.m., running the plant. After 11:00 a.m. Bob looked after all his outside work, or his inside work not listed as operating labor. Bob, as you see, received $130 a month net for his services. Since he operated the plant 4 hr. a day, Tom and Bob decided that 0.4 of Bob's $130 should be charged into operating labor, along with the helper's $200. The remaining part of the superintendent's salary, $78, they distributed, by estimating the time and importance of Bob's efforts, to "superintendence" of steam generation, of electric power generation, of water pumping, of transmission, distribution, consumption and commercial. What Bob's services consisted of, under these different departments, will be seen as they are reached on other sheets.

The basis of making this distribution of Bob's superintendence salary of $78 need not be explained, as your manner of paying your employes may be altogether different from ours. But you would have to get your employes' wages and salaries properly distributed to each department as nearly as you can.

The operating labor, totaling $252 a month, also had to be distributed to steam generation, electric power operation and water pumping operation. Tom and Bob decided that three-fourths of this should be charged to the boiler room, one-fourth to the power room. Of this one-fourth, they apportioned two-thirds to electric and one-third to water. Tom went back to his office and made a type-written statement of this distribution of the superintendent's salary, for future reference.

I might state, however, that Tom charged all of Bob's $130 to superintendence and none to operating labor. Formerly the superintendents made their helpers work 12 hr. a shift. Bob was a good-hearted fellow and took on 4 hr. himself so the helpers would have only 10-hr. shifts. The light and water committee made no objection, but considered that $130 of the superintendent's salary was for superintendence and $200 for operation. So Tom distributed it that way. Neither way was actually correct. For Bob did actually operate the plant, but he also superintended it while operating it.

Tom gathered the items of expense that would occur in a steam generation plant, from several sources. First, from his own experience and general knowledge; second, from further study of the Commission's booklet which gave lists of expenses that should be charged to various departments; third, from a study of the claims which the town had paid; fourth, by consulting the superintendent. He then tried to design a form that would properly display these expenses under their correct classifications and headings. He worked up, changed and destroyed many a work sheet before getting a form that satisfied him. This process of developing the cost accounting forms was followed for each form that he drew up. His complete set of forms, when worked out, consisted of five, of which this "steam generation" form is the second. It was drawn on a sheet of legal cap paper as was the "coal cost sheet" before described, and is shown in Fig. 2.

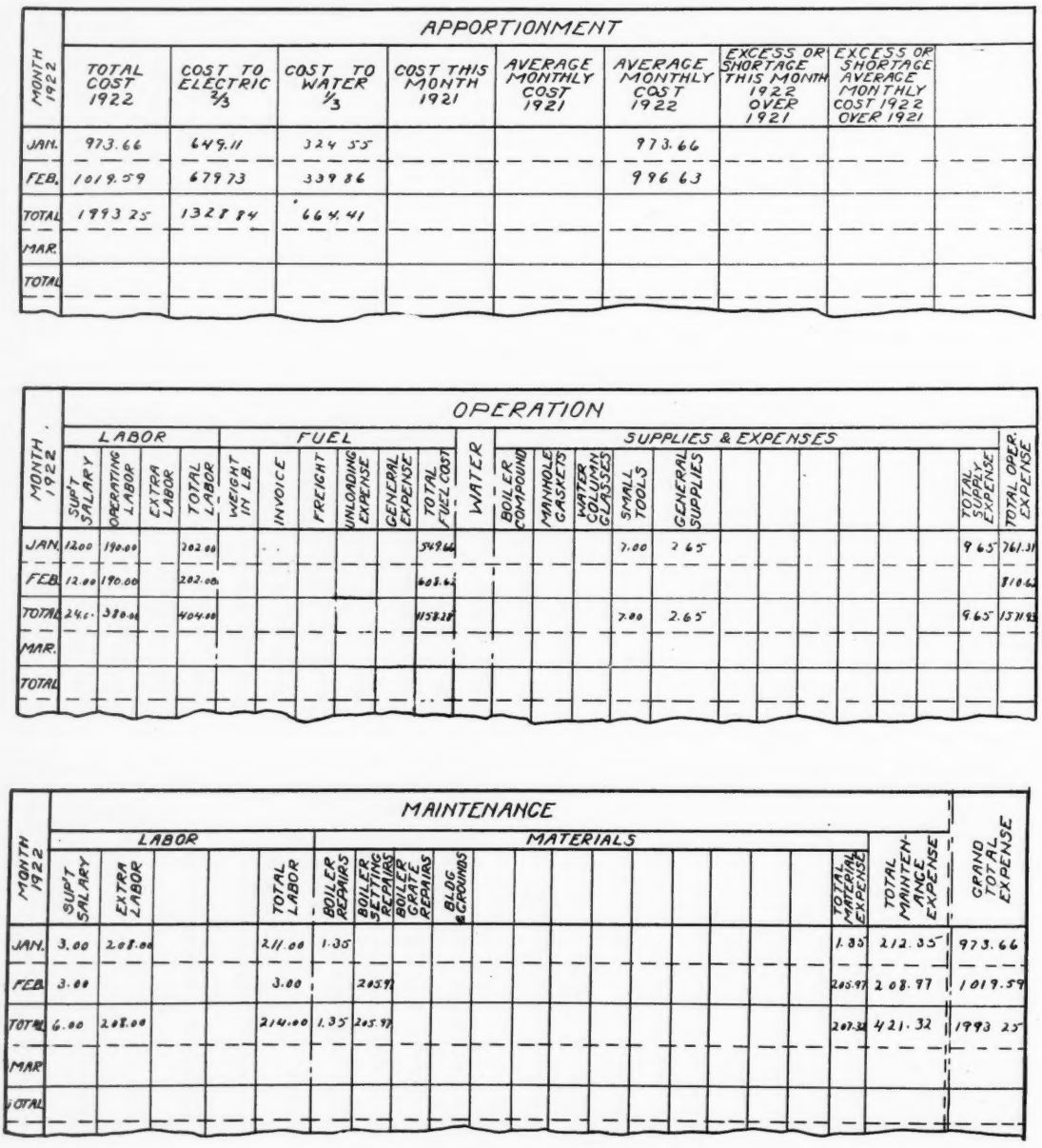
The sheet was ruled lengthwise (between the two marginal rulings with lines 5/16 in. apart); the first line was black; the second, red. The third, black, the fourth, red; and so forth. This made eleven divisions bounded by the red lines. He then ruled one more line lengthwise, 5/16 in. above the heavy marginal ruling. This, then, made twelve divisions—one for each month. Tom then ruled the sheet crosswise into columns two lines wide, for the first ten columns, and one line wide for all the remainder. Of course the legal cap paper is printed with blue lines, but they are too faint to make distinct differentiation of columns, nor do they extend above the heavy marginal ruling, as Tom desired. So he ruled all columns with a black pencil. He then subdivided this sheet into four sections, by red lines. The first section he entitled "Apportionment of Steam Costs"; the second section, "Operation"; the third, "Maintenance"; and the last, "Grand Total Expense." The second, third and fourth were the cost sheet proper.

The first section was the apportionment of this cost to electric utility and water utility, together with some other data as indicated on the sheet. The second and third sections were further sub-divided into sub-sections

by green lines as follows: In the second, or "operation" section, the 4th, 10th and 11th lines were green. The titles of the four sub-sections thus created were, labor, fuel, water and supplies and expenses. In the third, or "maintenance" section, the fifth line was green, thus making two sub-sections. The titles of these two sub-sections were labor and materials.

Entries were made on this cost sheet as monthly totals under the proper section, sub-section and column in black ink and on the black line of the proper monthly a three months' total, etc., for each column. Thus the sheet gave for each column, both the "cost this month" and the "total cost to date." Where and how these costs are to be gathered will be explained after all the sheets are explained.

After getting the grand total cost, in the last column, this is carried to the second column on the sheet, which is also the second column under the "apportionment" section. The third and fourth columns, "cost to electric," and "cost to water," were then filled in on a pre-



APPORTIONMENT

MONTH 1922	TOTAL COST 1922	COST TO ELECTRIC 2/3	COST TO WATER 1/3	COST THIS MONTH 1921	AVERAGE MONTHLY COST 1921	AVERAGE MONTHLY COST 1922	EXCESS OR SHORTAGE THIS MONTH 1922 OVER 1921	EXCESS OR SHORTAGE AVERAGE MONTHLY COST 1922 OVER 1921	
JAN.	973.66	649.11	324 55			973.66			
FEB.	1019.59	679 73	339 86			996 63			
TOTAL	1993 25	1328 84	664.41						
MAR.									
TOTAL									

OPERATION

MONTH 1922	LABOR				FUEL						WATER	SUPPLIES & EXPENSES										
	SUPT SALARY	OPERATING LABOR	EXTRA LABOR	TOTAL LABOR	WEIGHT IN LB.	INVOICE	FREIGHT	UNLOADING EXPENSE	GENERAL EXPENSE	TOTAL FUEL COST		BOILER COMPOUND	MANHOLE GASKETS	WATER COLUMN GLASSES	SMALL TOOLS	GENERAL SUPPLIES					TOTAL SUPPLY EXPENSE	TOTAL OPER. EXPENSE
JAN.	12.00	190.00		202.00						549.44					7.00	2.65					9.65	761.31
FEB.	12.00	190.00		202.00						603.62												817.62
TOTAL	24.00	380.00		404.00						1153.06					7.00	2.65					9.65	1579.93
MAR.																						
TOTAL																						

MAINTENANCE

MONTH 1922	LABOR					MATERIALS												TOTAL MATERIAL EXPENSE	TOTAL MAINTENANCE EXPENSE	GRAND TOTAL EXPENSE
	SUPT SALARY	EXTRA LABOR			TOTAL LABOR	BOILER REPAIRS	BOILER SETTING REPAIRS	BOILER GRATE REPAIRS	BLDG & GROUNDS											
JAN.	3.00	208.00			211.00	1.35												1.35	212.35	973.66
FEB.	3.00				3.00		205.97											205.97	208.97	1019.59
TOTAL	6.00	208.00			214.00	1.35	205.97											207.32	421.32	1993 25
MAR.																				
TOTAL																				

FIG. 2. STEAM GENERATOR COST SHEET

"division" described in detail somewhere above. The January division had only one line, you remember. The other monthly "divisions" had two lines, a black line above and a red line below. On the red line was entered in green ink, the "total to date" of each column. That is, February division carried a two months' total, March determined percentage ratio. Tom and Bob had discussed this ratio at length. Having no steam flow meters, it had to be purely an estimate. As the electric service was a twenty-four hour service, they decided that two-thirds of the steam cost should be charged to electric and one-third to water. The remaining columns

under "apportionment" were readily filled in and the monthly record completed. These columns, the fifth to ninth inclusive, are very important. They show whether the costs are getting exorbitant and whether an investigation should be made to find the trouble and means of reducing the costs.

This steam generation sheet may not contain all the items of expense which your boiler room has. It will be a simple matter for you to add more columns under any sub-section to take care of your additional expenses, or even to make more sub-sections, or sections, if required. Should the legal cap paper not be long enough to hold all your sections, just paste on some more of it at the end, and rule to suit. Tom left blank columns, occasionally, in case he should need them for expenses he did not foresee.

The next cost sheets worked out by Tom were the "Electric Utility Cost Sheet" and the "Water Utility Cost Sheet." The "coal cost sheet" gave us one item to enter on the "steam generation cost sheet," viz., "cost of fuel." Likewise the "steam generation cost sheet" gives one item to enter on the "Electric" and "Water" sheets, viz., "cost of steam." But these are not the only uses for the first two sheets. These are an important, but not the major use. The "coal cost sheet" will prevent you from paying for a car of coal twice, as the town of Kineford once thought it had. The two sheets studied together will show whether lump, egg or screenings is the cheapest kind of coal to burn. Whether Indiana screenings at $5, Illinois screenings at $5.50, or Kentucky screenings at $6 is the cheapest. It will show whether 4th, 5th or 6th vein is the cheapest. It will show whether February, 1921, used more coal than February, 1920. If so, then the superintendent can investigate the master meter readings for these months and see if the consumption was greater in 1921 than in 1920 and see whether this explains the use of more coal. An intelligent study of these two cost sheets will bring to light many secrets hitherto hidden. Especially will this be true, if the superintendent weighs his coal used at the boiler each day and weighs the ashes made. Or at least does so periodically and keeps a permanent record of these findings.

(To be continued)

Oil Engine Hints

PROPORTIONS, INSTALLATION ARRANGEMENTS AND OPERATING KINKS TO MAKE THE OIL ENGINE OPERATOR'S LIFE RUN SMOOTHLY

BY CAREFUL attention to the details of arrangement and installation, and by a carefully planned routine of operation and inspection, the engineer who has charge of an oil engine plant can greatly reduce the work that has to be done in the plant and the worry of keeping it tuned up to top notch. As one inspired writer puts it, "most accidents unwind." There is a little end comes loose somewhere in the equipment or operation of the plant, and if it isn't taken care of at the time, it just ravels out and unwinds until there is a serious hole which catches and results in a big tear. That takes a long time and much trouble to mend, but the loose end could easily have been caught up and the tear prevented if somebody had been on the watch to catch it at the first sign of unwinding, or, better, had seen that there was a weak spot and darned it before ever the end got loose at all.

OIL SYSTEM

TAKING UP first the oil system for both fuel and lubrication; it is best to use large pipe for long lines as this cuts down the drop in pressure, reduces the power for pumping and lessens the chances of clogging. A big pipe lets impurities or foreign matter pass through so that they can be caught in a trap or strainer which should be so located that it can be readily inspected and cleaned. Of course the piping should be as short and free from turns as possible and should be arranged with the idea that it may have to be taken down or altered; but as it stands, it should be the best job possible for present purposes. When it is taken down for any purpose, a lot of trouble will be saved in reassembling, if the male threads are covered while the pipe is being handled so as to avoid mashing the thread.

Fuel oil for a Diesel or semi-Diesel type may be almost any gravity, but if heavy must be heated, generally by the outlet jacket water so as to atomize freely. The grade most used runs from 20 to 30 deg. gravity at 60 deg F. temperature, with flash point of 125 to 250 deg. and burns at 160 to 300 deg., though these temperatures are not of great importance. Sulphur should not be over 1.5 per cent, as there is a tendency to form sulphuric acid which will corrode the cylinders; water should not be over 0.3 per cent and ash not over 0.01 per cent, for ash will score the cylinders, if present to any appreciable amount. If an oil of lower gravity is used, heating it will raise the gravity, an oil which shows 20 deg. at 60 deg F. becoming 22.5 deg. gravity at 100 deg. F and 23.7 gravity at 120 deg F.

Fuel consumption per horsepower hour should be tested occasionally to make sure that the plant is in good condition and adjustment. As a basis for comparison, the consumption usually expected is about as given in the following table:

POUNDS OIL PER BRAKE HORSEPOWER PER HOUR

Type of Engine	Per cent Rating 30	50	70	90	100
4-cycle	0.56	0.47	0.42	0.405	0.41
2-cycle	0.66	0.56	0.50	0.48	0.475
Semi-Diesel ...	...	0.75	0.65	...	0.50

Special care should be given to the fuel pumps, as on these depends the smooth operation of the engine. The pump well should be kept clean at all times, and the oil strained before it enters the well. Suction valve stems should be packed just tight enough to prevent leakage but no tighter. The pumps should be taken apart for examination at least every month and if the seats are found to be cut, they should be carefully reamed. The discharge valve is usually a ball which should have a lift of not over 1/16 in. If it becomes greater, a new cage should be provided. The ball valve

can be seated by a single light tap of a hammer without injury to valve or seat, after the seat has been reamed with a 45-deg. reamer.

When replacing the parts of the pump, all leaks must be avoided, and the pump should be able to hold a pressure of 1125 lb. on the discharge side without running down. To make this test, disconnect the discharge end and connect a gage as a dead end; pump up the test pressure by hand and this should hold constant for a considerable period.

To be sure of ample supply of fuel at the cylinders each pump should have capacity of 2 to 4 times that

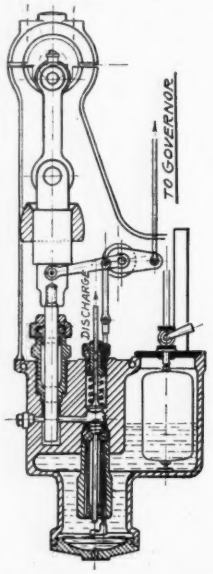


FIG. 1. SECTION OF FUEL PUMP, FROM GOLDINGHAM

required to furnish ½ lb. of oil per horsepower-hour for the full rating of its engine cylinder.

For lubrication with the flooded system, there should be an elevated tank of large capacity from which an oil main and branches lead to all engines. At the bearings are sight feeds adjustable by hand, the oil being returned to filters and pumped to the elevated tank. It is best to have a pump for each engine, drawing from the filter settling tank and discharging to the oil supply branch to that engine. In this way, there is oil circulation whenever any engine is running; the tank is kept filled, yet if there is any stoppage in the line from the tank, the engine will still get oil from the pump. There should be bypasses from one engine main line to another so that if one pump breaks down, its engine can be supplied from another pump. Where a single unit is used, or when the engine is oiled by forced feeding of the oil, each engine has its own self-contained system, and inspection of the system should be frequently made to see that oil is reaching all bearings. Also the strainer must be cleaned frequently, as a stoppage or reduction of the area of the strainer will result in insufficient supply of oil.

For large engines, where the piston heads are cooled, many makers prefer to use oil for such cooling, as it avoids the danger of getting water into the crankcase. Oil used for this purpose should be supplied from a pipe system separate from the lubricating oil, though it may be handled by the same pump and filter. It should have an outlet temperature of not over 120 deg. F. which will require a flow twice as great as for water cooling, and a large oil cooler must be used, through which the cooling oil should be passed before returning it to the filter.

When cleaning out the oil system, never use waste for wiping. A few threads caught in a pipe or pump may stop the operation of the whole system. Always use rags and be sure that all ravelings are cleaned off them before using.

Where the splash system is used, the crankcase should be cleaned out every 6 mo., and the oil inspected frequently between times. The oil level should be tested through the feel hole each morning, and at intervals through the day. The bottom of the case is filled with several buckets of water, depending on the size of the engine, and on top of this is the lubricating oil. In a run of 4 hr. it will usually be necessary to supply lubricating oil and water to the crankcase, to keep the oil level at the proper height. The makers will furnish information as to the proper amount of water and oil to put into the crankcase when refilling, and the same thickness of oil layer should always be maintained.

When the oil is inspected, by taking a sample from the crankcase for examination, if it has a greenish tinge in the sunlight it is in good condition, but if it is black, the crankcase should be cleaned out and refilled. To do this, the covers are taken off, the water and oil bailed

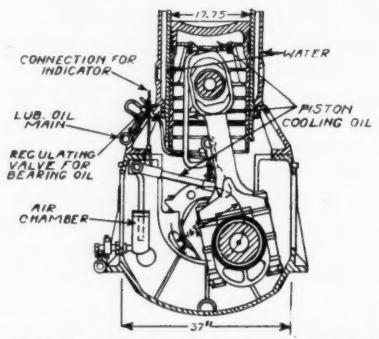


FIG. 2. OIL COOLED PISTON OF DIESEL SUBMARINE ENGINE USED BY U. S. NAVY, FROM LUBRICATION

out as much as possible, and it is then advisable to run for say 5 min. at slow speed to watch for any lost motion. If any is found, it should, of course, be taken out. Next, put in the amount of fresh water usually used in the case, and on top of this 3 or 4 pails of fuel oil. Put on the covers and run the engine for 15 min. to wash out the bearings and all the corners of the crankcase; then shut down, remove the covers and bail out the oil and water which is to be thrown away. Wipe off all parts as clean as possible with rags and refill with fresh water and oil, using the amounts specified by the makers of the engine.

Piston and compressor cylinder lubrication are usually by force feed. For the engine piston, a high grade of cylinder oil is needed with flash point not less than 500 deg F. As little oil as will serve to keep the piston lubricated should be used, for an excess tends to gum up the rings and valves and form carbon in the cylinder. In the compressor cylinder, excess oil may also be the cause of explosions, and it is advised by one authority that for a three-stage compressor, 1 to 2 drops

of oil a minute be fed to the 1st and 2nd stage cylinders and none to the 3rd stage. In any case the amount should be just enough so that the walls of the cylinders feel oily when taken down for examination—and no more. Only new oil should be used in the engine and compressor cylinders; use the filtered oil for bearings.

Air System

For furnishing the injection air for a Diesel engine a compressor is usually attached to the shaft of the engine, of two-stage or four-stage type, though the three-stage is sometimes used. The air is cooled between stages and after compression to save power in compressing and to throw down water which is carried in suspension. Care should be taken that there are no sulphur fumes in the air which is drawn into the compressor, as this will cause the formation of sulphuric acid in the engine cylinder.

For a four-stage compressor, the low pressure side should have a volume 5 per cent of that of the power cylinder of the engine; for a two-stage compressor, this volume should be 10 per cent that of the power cylinder. In either case, the compressor should be able to supply 18 cu. ft. of air per hour per rated horsepower of the engine. The compressor will take about 10 per cent of the power developed by the engine to drive it.

For starting two-cylinder engines, air is used in both cylinders, but for four-cylinder engines, only in two. The starting valve should be set so as to admit starting air from dead center to 90 deg. crank position, and the air should be left on only until the engine fires, then immediately turned off and the fuel turned on. In the two-cylinder engine, the air is turned off and fuel turned on in both cylinders when the engine is up to speed, unless the starting system is so arranged that air may be turned off one cylinder after speed is reached, and that cylinder be allowed to get into action with fuel, when the second is turned from air to fuel. In this case, the switching of the two cylinders will follow close together, and it is of doubtful value to separate the action of the two cylinders.

To store the air for injection for the next start, a tank will be required having a capacity of 0.035 cu. ft. per brake horsepower of the engine; and for the starting air to turn the engine over, the tank capacity should be 0.35 cu. ft. per horsepower.

For a two-cycle engine, air must be compressed for scavenging to a pressure of 4 to 5 lb. For small engines, this is frequently done in the crankcase by the in stroke of the piston, but for larger engines it is better to have a separate compressor. This should have a cylinder volume 1.4 times that of the power cylinder, and is of course, single stage.

Water System

Water should be tested and if found to contain matter which will corrode the jackets or form a large amount of scale should be treated before using. The amount needed will depend on the initial temperature, as the final temperature for small four-cycle engines is usually limited to 160 deg. and for large two-cycle engines to 120 deg. The former would require 4 to 5 gal. per hr. per brake horsepower, and the latter 5 to 10 gal. For 25 deg. rise in temperature, the water needed will be 14.5 gal. per hp.-hr.; for 50 deg. rise, 7.5 gal.; for 75 deg. rise, 4.7 gal.; for 100 deg. rise, 3.5 gal.

There should be a visible outlet for the water from each jacket so that the circulation can be watched, and a thermometer should be provided to register the outlet temperature. Water inlet should be provided with diameter equal to the square root of (0.02 times the brake horsepower per cylinder.) Diameter of the outlet should be 1.5 times that of the inlet.

In case the water supply fails for any reason, do not turn water into dry, hot jackets as the result is almost sure to be a cracked jacket or cylinder liner. If the jacket becomes scaled, this may be softened by boiling with a strong solution of soda ash, washing out afterwards with a strong current of water. For a water which tends to form heavy scale, treatment with a high grade of fine graphite and with kerosene will tend to keep the scale from adhering to the jacket walls.

When using the soda ash method for cleaning jackets it is best to get a cooling tank of rain or other pure water having a capacity of 20 gal. per hp. In this put

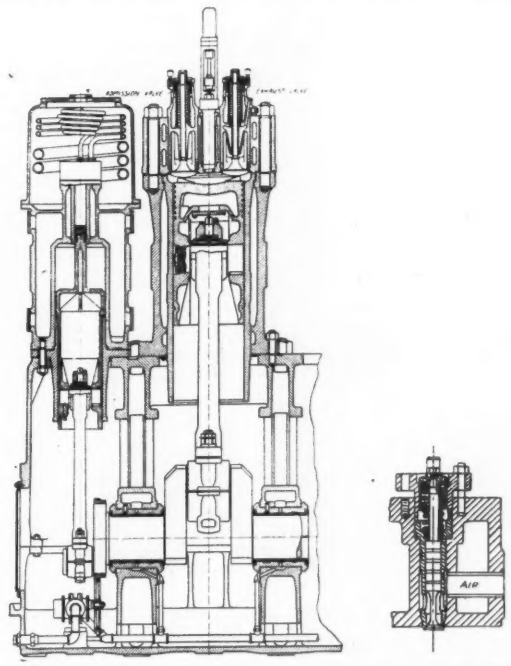


FIG. 3. SECTION OF BUSCH-SULZER AIR COMPRESSOR, MEGSON AND JONES

FIG. 4. TYPICAL AIR STARTING VALVE, FROM GOLDINGHAM

1 lb. of caustic soda per 5 gal. of water. This arrangement can be used for cooling until the jackets are free of scale or can be continued indefinitely if the water available for cooling is too bad to use without treatment.

Arrangement of Plant

When planning for the location of the engine, be sure that there is plenty of room above and at the sides for the removal and replacement of any of the working parts of the engine without tearing down walls, permanent floors or partitions. For a large machine, there must be overhead room sufficient to use a crane or lift for taking off the heads and taking out the pistons and connecting rods.

The floor should be painted or otherwise treated so as to be dustless, else the work of keeping the engine clean and in good condition will be greatly increased.

Where the engine is used to drive a generator, the work of starting and operating will be greatly simplified, if the generator can be so connected as to act as a motor when starting up. This is possible only where there are two or more units and one is running when the other is started up, or where a large storage battery is part of the plant equipment.

In planning foundations for an engine, it is well to check against the following figures which are the result of experience. For a one-cylinder engine the foundation should contain at least 2000 lb. of masonry per horsepower. For a two-cylinder engine, 1750 lb. per hp.; for three cylinders, 1300 lb.; for four cylinders, 1100 lb. Another rule which gives a slightly heavier foundation is that for a 100-hp. engine, the foundation should have 40 cu. yd., and for 500 hp., 125 cu. yd. The pressure exerted by the full weight of engine and

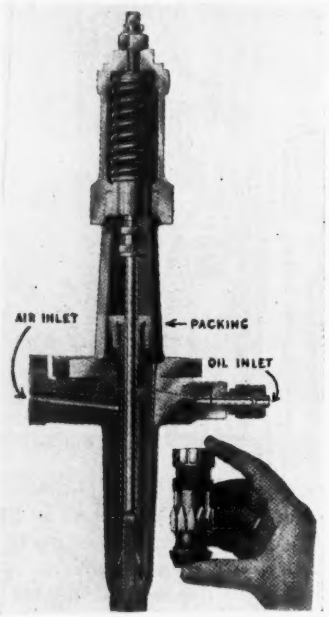


FIG. 5. NEEDLE VALVE AND CAGE OF MCINTOSH AND SEYMOUR ENGINE AS SHOWN IN LUBRICATION

accessories on the foundation should not be over 50 lb. per sq. in. The depth of the masonry should be 5 times the cylinder diameter to resist the bending strain from the reciprocating action.

Keeping Fit

Watch for leaks. They are the invention of the devil and his first line of attack on your peace of mind. At the air inlet or exhaust valves, the leak is usually betrayed by a whistling noise; the leaks around cylinder head gasket or valve gage gaskets will be shown by the escaping air bubbles; the relief valve will betray its distress by the noise of escaping air; and a leak in the air starting valve will be indicated by the pipe below the valve being hot. On a two-cycle engine the scavenging air valve will sometimes leak, and will be noticed because there will be a continued hiss of air through it even when it is supposed to be closed.

Leakage past the piston will be shown in an open-end cylinder by a sneeze past the piston at every explosion. When the lower end of the cylinder is enclosed by the crank housing, it is not so easy to detect a piston leak, but there will be a smell of burnt gases in the crank case when it is opened. Also when the piston is taken out, there will be blackened spots on the rings. A leaky atomizer will cause unburned oil in the exhaust, but this may also come from a cold igniter bulb.

Sometimes you will be pestered with a spell of bad regulation; this is most likely to be from the governor getting out of order or not being lubricated properly. It may also come from one or more cylinders having a leak in the fuel system so that a full supply of fuel is not received, or from a variable injection air pressure. If one cylinder of a multicylinder engine persists in missing, it will usually serve for the rest of the run, to cut off the fuel on that cylinder and let the others carry the load, but the cause of the missing should be discovered and remedied before starting up again.

Low compression comes from too large clearance or leakage. If it is a new engine, the former is most likely the cause and the clearance should be adjusted by disconnecting the connecting rod and inserting shims to lengthen it. Try a shim and note the effect on the compression pressure as shown by the indicator card or a registering gage; then change to get the desired effect. If it is an old engine and has had proper compression, the chances are that low compression is due to the development of a leak. The places to hunt it are at the exhaust valves, air valves and gaskets, piston rings and air starting valve. If a piston ring leak is found, it may be remedied by peening the ring against a flat surface with a light ball peen hammer, taking care to give all parts the same treatment so as to maintain an even pressure at all points of the ring. It is well also to caliper the cylinder carefully on all diameters and at various points of its length. If it is found to be oval or barrel shaped, it should be rebored and new pistons and rings fitted.

Semi-Diesels

These, of a type using slow burning but not so high compression as Diesels, call for some special consideration. They are mostly of two-cycle type with compression to from 150 to 210 lb. If the pressure drops as low as 100 lb. it is likely to result in irregular firing. As a consequence, it is not permissible to throttle the air inlet, but power must be governed by regulating the amount of fuel fed, giving a full charge of air each stroke.

The engine should be run hot, with outlet jacket water at 180 to 200 deg., so as to maintain good firing conditions. To accomplish this, it is usual to pass the water through the jacket of the exhaust manifold on the way to the jackets. The temperature of the charge at compression pressure should be kept as high as 500 deg., which will be accomplished if the pressure is kept up to 150 lb., corresponding to 589 deg. for an atmospheric temperature of 60 deg.

In the solid injection type, the fuel is pumped into an elastic fuel pipe of oval section at a pressure of 4000 to 8000 lb. The pipe is placed along the side of the cylinder with a small branch to each inlet valve. When an inlet valve opens, the spring of the pipe forces the fuel into the cylinder through a hemispherical nozzle

with radial holes 0.015 in. diameter, one hole being used for each 300 cu. in. of piston displacement, and the holes arranged to give a rose spray.

It is found best to have the holes in thin metal so as to give a wide spraying effect; and a spring loaded admission valve is best, as it closes quickly, preventing dribbling at the end of admission.

Most of the trouble found with semi-Diesels is from clogging of the nozzles due to dirty fuel, and the obvious remedy is to use plenty of fine copper gauze strainers and keep them clean. When the engine lies down, look for dirt. Using a fuel pump with a short, quick stroke will also tend to break up the spray and dislodge dirt which may find its way into the system, but cannot take the place of keeping dirt out.

Spare Parts

It is essential to have certain spare parts on hand both for regular operation of the engine and for emergencies. To keep the needle valves in best condition, they should be taken out and reground regularly, and the most convenient way to do this is to have a spare valve, cage and gasket for each cylinder. The spares can then be kept always ready for use in case of emergency, and can be exchanged at regular intervals for those in use, which in turn are put in perfect condition and held in reserve. The valve should be ground so that it shows a bright ring of seating 1/32 in. wide all around the seat, and in reaming the seat care should be taken that there is no chattering of the reamer.

There should be at least one spare admission valve and cage and the same for exhaust. These should be put in perfect condition, grinding the valve and reaming the seat to fit so that when pencil marks are made on the seat at ½ in. apart, a half turn of the valve on the seat will erase all of them. There should also be a spare atomizer which can be inserted in case of clogging or other bad action, so that the balky part may be brought to a tractable state of activity at leisure. A set of springs for all valves should be on hand in case of breakage, spare gaskets, of course, for all joints and at least six new piston rings, the more the better within reason, for one can never tell when it may be desirable to put a new set in all cylinders at once.

For the fuel pumps, it is wise to have a spare plunger and suction valve for each pump. The fuel pump is the heart of the engine, and if a plunger or valve goes wrong and cannot be replaced, that cylinder is down until a new one comes. Even if it is possible to fix up the plunger or valve, it is not likely to fit in any other pump on account of the wearing to fit which has taken place, hence these parts cannot be considered as interchangeable among the different pumps. The plunger or valve may be put in condition to use again in the pump from which it came, and can be kept as a spare for that pump, carefully labeled so that there will be no mistake as to where it belongs.

Finally, study your plant all the time to learn its peculiarities. Every engineer knows that each machine has certain individual characteristics and has to be handled a little different from any other to get the best results. Watch for the points where your machinery is likely to develop trouble, and meet the trouble before it comes.

Method of Weighing Attached Irregular Parts

By W. F. Schaphorst

Occasionally it is desired to know the weight of some part on a machine, but the part cannot be detached easily for weighing and it is too irregular to compute with ease. In such case, the weight can be found indirectly by weighing the water displaced by the part, if the part projects in such a way that it can be made to displace water.

For example, the writer once had to determine the weight of a flywheel governor weight, which was made of cast iron, and which could not be detached without removing the whole governor from the engine.

I turned the flywheel to such a position that the weight was at its extreme low point. I then procured a rectangular sheet metal vessel and filled it with water. I weighed the vessel of the shape indicated and filled it with water. I weighed the vessel when it contained as much water as could be held in it.

Then I carried the vessel of water over to the engine and raised it so as to envelop the weighted end. Water was displaced, of course, but that is what was wanted. I raised the vessel until the water level cut the governor arm, being sure all the while that the vessel was still holding as much water as possible while raised to that height.

Then I removed the vessel and again weighed it, this time with the remaining water. The weight of the governor end was then computed in this manner:

The first weight was 45.5 lb. and the second weight was 39.25 lb. The weight of the water displaced was therefore $45.5 - 39.25 = 6.25$ lb.

Now to compute the weight of the cast iron that displaced the water, all that is necessary is to multiply by the specific gravity of cast iron, which is 7.207, or $6.25 \times 7.207 = 45$ lb.

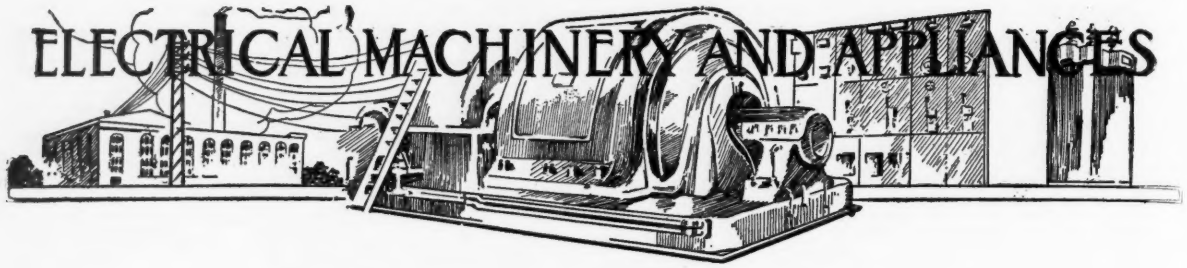
The remainder of the arm was of rectangular cross-section, whose weight was very easy to compute on the basis of 0.26 lb. per cu. in., which is the weight of cast iron.

In case other metal parts are to be weighed in this manner, here are the specific gravities of metals most commonly used in mechanical construction:

Cast iron	7.207
Wrought iron	7.78
Soft steel	7.833
Steel castings	7.917
Cast aluminum	2.60

Should it be desired to know the volume of the piece of metal in cubic inches, divide the difference in weight (which is equal to the weight of the displaced water) by 0.0362. The result is the volume of the part in cubic inches.

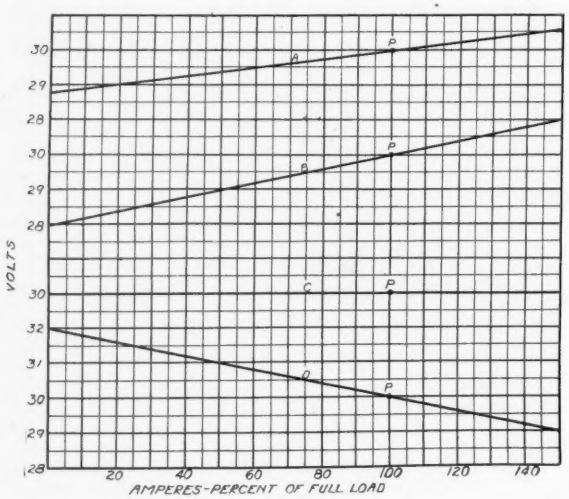
This latter test will come in handy for finding the volume of any irregular substance that can be submerged in water without harm or without any absorption of water. Or, should one wish to find the specific gravity of coal, brick, rock, etc., this method, reversed, will serve the purpose. Weigh the rock, say, and then weigh the displaced water (which can be done by subtraction as already explained). Divide the former by the latter and the quotient is the specific gravity of the rock or other substance.



Generators for Charging Batteries

TYPES EMPLOYED, THEIR CHARACTERISTICS AND PROTECTION. BY H. M. PHILLIPS

THE GENERATOR used for battery charging is almost invariably direct connected to a motor. The engineer who has motors available will quite frequently be able to use one as a generator, preferably separately excited, and produce a fairly efficient outfit. It is unlikely, however, that it will be quite as well adapted to the service as a set that is designed to meet the exact requirements; the probabilities are that for a permanent installation it will be economy to purchase an equipment embodying all desirable features. Although due consideration should be given to the saving in cost, especially in a set of small capacity, that



CHARACTERISTIC CURVES OF STORAGE BATTERY AND GENERATORS WITH DIFFERENT TYPES OF WINDING

will result from buying a stock article; there are a number of interesting variations that are more or less at the option of the purchaser. We should at any rate know in advance the type of machine that will be furnished.

Should the generator be shunt or compound wound? There is a popular impression that *all* generators should be compound wound; that heavier overloads can be carried and better current adjustment obtained with the compound winding. As a matter of fact, about the only good of a compound winding on any generator is to avoid excessive fluctuations of voltage. The same overload capacity can readily be obtained from a shunt field that is designed for such service; in a compound wound generator, the shunt winding is designed to furnish only a part of the magnetizing force and the capacity is naturally reduced if the series winding is cut out of circuit. If the generator is always to operate considerably below its rated voltage, as may be the case when utilizing a generator designed for another purpose, it is decidedly better to cut out the series winding in order to prevent heavy over-compounding.

The compound wound generator, although occasionally used for battery charging, has nothing in its favor and several serious disadvantages. If self excited, it is likely to reverse its polarity whenever the battery finds an opportunity to send a reverse current through the windings. It may also run at excessive speed, possibly bursting the armature, when driven as a motor by the battery. In case of a short circuit, it delivers a heavier current than a shunt wound generator, with correspondingly increased danger to itself or other apparatus. Under normal operating conditions, it is more difficult to get the desired current adjustment with a compound wound generator, as illustrated by the accompanying curves. In curve A we have the variation of voltage with charging current for a battery of rather low internal resistance; curve B shows the voltage curve of a generator compounded for about 7 per cent rise in voltage. When charging at the rate represented by the point P on both curves, it is evident that a momentary interruption of current would throw the voltage of the generator below that of the battery, which would immediately begin to drive the former as a generator; in fact, any slight reduction of current, such as would be produced by the normal increase of battery voltage while charging, would reduce the voltage of the generator and cause the current to fall still further, bringing about the same condition as before. On the other hand, a slight increase of generator voltage, due perhaps to a change in speed, would increase the current with a corresponding additional increase in voltage, both current and voltage rising until a heavy overload is attained. The system would be in unstable equilibrium and it would be impossible to operate. If the slope of curve B is less than A, the system will cease to be unstable but will have a greater tendency toward current fluctuations as the two curves become more nearly parallel.

Curve C in the same figure shows the voltage curve of a generator with flat compounding and D that of a shunt wound generator; the superiority of the latter may be best illustrated by assuming a 20 per cent change in current either by rheostat adjustment, change of

speed or other cause. This change of current would change the battery voltage (curve A) by 0.24; a very slight change of field resistance or of generator speed would be sufficient to raise curve C by that amount, making it correspondingly difficult to hold the current at that or any other definite figure.

With the shunt wound generator the change in battery voltage would be the same as before, but there will be an additional change of 0.40 on curve D, making a total of 0.64 v. to be produced by a change in field resistance or speed, a much less sensitive adjustment. It should be noted also in reference to curve C that it is practically impossible to build a generator that will give straight line regulation; if the full load and no load voltage are the same, there will be intermediate points at which the voltage is either higher or lower and on the upward trend of the curve the sensitiveness of adjustment will be correspondingly increased. Also, if the generator is adjusted to "flat" regulation at normal voltage it will show over-compounding when the voltage is reduced.

All this seems to indicate the desirability of connecting the series field in opposition to the shunt and producing a voltage curve with a more rapid fall than that of the shunt wound machine. This practise is followed in the design of automobile generators, which give an approximately constant charging current although running at an extremely variable speed; it might also be used to advantage when utilizing a generator whose normal voltage is considerably above that of the battery to be charged; but for ordinary conditions the advantage is not sufficiently great to justify the use of the larger and more costly generator that this connection would demand.

If for any reason a compound generator is considered necessary, it is generally best to have this winding designed for connection in the armature circuit of the driving motor (provided it is direct current) instead of the generator armature. This reduces the tendency to over-compound when running on reduced voltage and is also a very good protection against reversal of polarity.

When direct current other than that obtained from the charging generator is available, it is a decided advantage to have the generator fields designed for separate excitation. The voltage of the ordinary self-excited generator becomes unstable at about 40 or 50 per cent of its normal voltage and although a generator may be designed to operate at lower voltages, it is apt to be more expensive. With separate excitation and properly designed inter-poles, the generator will operate at practically any voltage desired. In addition to the foregoing, the voltage will usually be less likely to show fluctuations and the polarity of the generator cannot be reversed by the battery.

In specifying the capacity of a motor generator set, careful consideration should be given of the exact operating conditions. Recognition of the fact that the maximum amperage is not required at the same time as the maximum voltage may in some cases effect a considerable saving in first cost. For example, the maximum amperes required for charging a certain battery may be 100 and the maximum voltage 30, but the 100-amp. current will not be used at more than 27 v., while only 50 amp. will be used at the higher voltages.

In the majority of cases, a generator for this service would be identical with one from which 100 amp. at 30 v. is required, but occasionally the manufacturer will find that a generator of a certain size will deliver 100 amp. at 27 v., but is unable to maintain the same current at a higher voltage, in which case it becomes necessary to use the next larger motor frame, with considerable increased cost for 100 amp. at 30 v. It is much the same with the motor; in one case the maximum generator output is 2.7 kw., in the other 3 kw. The difference is so small that usually the same motor would be used in either case, but there must be a dividing line somewhere and when it falls between the two values a heavier motor is required for the larger output.

As noted in a previous article, when batteries are charged off a 115-v. line by means of a rheostat there is a marked saving in power by charging two or more in series. With a motor-generator set, it would be necessary to double the capacity of both motor and generator, adding materially to the first cost. When charging a single battery, the set would run at half load, with efficiency considerably lower than would be obtained from a set of half its capacity. If it is necessary to charge two or more batteries at the same time, the best results will be obtained by increasing the current capacity of the generator and charging in parallel instead of series; if a rheostat of very low resistance is placed in series with each battery, it will afford independent current control for each.

Although it may be desirable at times to charge a single cell; it may be preferable, or necessary, to do so by the introduction of a resistance unit rather than by reduction of generator voltage. This is pretty certain to be the case with a self excited generator, while with the separately excited generator there is a possibility of commutation trouble on very low voltage. Data should be obtained from manufacturers as to the minimum voltage at which the generator will operate satisfactorily while delivering the desired current. A resistance unit for what further reduction may be necessary will be comparatively inexpensive.

Protective devices require careful consideration of operating conditions, the possibility and probability of accidents and the damage resulting therefrom. The motor will of course require the usual overload protection; fuses, circuit breaker or overload relay according to the fancy of the engineer or the control apparatus accompanying the motor. The overload device on the motor affords some degree of protection to the generator also; if the latter were built for constant voltage, it would hardly be necessary to provide separate overload protection, but as the voltage is reduced from the maximum there is a corresponding increase in the current that the generator can carry without producing an overload on the motor; on very low voltage the generator could be burnt out quite quickly without overloading the motor. The writer is of the opinion that the circuit breaker on the generator might advantageously be omitted more frequently than it is; an actual short circuit, even with a very considerable reduction in voltage, should blow the breaker on the motor; while with ordinary attendance, the chances of a long continued overload are rather remote. The circuit breaker may add materially to the first cost and if exposed even slightly to acid fumes requires considerable attention

to keep it in good condition; the elimination of both these items may compensate for the remote possibility of a burn out.

The possibility of the battery discharging through the generator must always be considered; the degree of protection required depending upon operating conditions for the individual case. Among the possibilities, the following may be noted:

(1) A reversal of generator polarity, or connecting the battery on wrong polarity. The effect is practically the same as a short circuit, on both battery and generator, and the circuit breaker on the motor may give sufficient protection.

(2) Failure of current supply for the motor. In some cases, this may occur several times a day; in others, so rarely as to need no consideration. The effect will depend upon the type of generator and manner in which it is connected.

(a) A self excited shunt wound generator will continue to run as a motor, with speed slightly reduced. The motor, if direct current, will probably maintain its field excitation and act as a generator. When the conditions are such that the motor generates on open circuit, the set will be driven by the battery with a comparatively small current and no harm other than the gradual discharge of the battery will ensue. On the other hand, it is quite probable that other motors will remain connected on the same line as the charging set, in which case the motor will probably generate enough current to blow its own circuit breaker, making the same condition as before. Between the two, we may have a load insufficient to blow the circuit breaker, but enough to produce a rapid discharge of the battery.

(b) With a separately excited, shunt wound generator, if failure of line voltage causes loss of field excitation. As this loss is rarely if ever instantaneous, the generator becomes a motor with very weak field, which will be driven by the battery at a dangerous speed unless held down by the motor. If there is an overload circuit breaker in the battery circuit it will probably open before the speed is sufficient to burst the armature.

(c) The compound wound, self-excited generator on reverse current has the compound winding opposed to the shunt, which causes a weakening of the total field with increasing current and a corresponding increase in speed; in extreme cases the effect of the series field may become greater than the shunt, causing a sudden reversal of rotation. In any case, the speed or load will probably become dangerously high if the current is not interrupted in time. It is probable that the polarity of the generator will be reversed when next put in operation. If the generator is separately excited, it will run as a series motor, with reversed rotation, and may attain a dangerous speed on no load.

(3) The opening of the motor's circuit breaker has the same effect as failure of line voltage except that it is impossible for the motor to send current back into the line. (See (2) above).

(4) Throwing the battery on the charging line before the generator is started has the immediate effect of short-circuiting the battery through the armature of the generator. If the generator is compound wound it will start as a motor and probably attain a dangerous speed; if self excited, the polarity will be reversed when again started as a generator. With a shunt wound generator, the probabilities are that it will not start, but if it does, it is likely to attain a dangerous speed very quickly.

(5) Generator voltage below that of the battery, either when the battery is thrown on the line or during the operation of charging, which may occur from carelessness in manipulating the field rheostat, causes a reverse current whose volume depends upon the difference in the two voltages and causes a more or less rapid discharge of the battery. If the generator is compound wound, the reverse current weakens the field and a rapid discharge, approaching short circuit, is almost sure to occur.

A simple overload circuit breaker in the battery circuit secures protection against the most serious consequences in any of the cases noted above, but does not guard against reversal of the generator or the more or less rapid discharge of the battery as described in (2) and (3) above.

The under-load circuit breaker offers very satisfactory protection in all cases except (1) and (5) above. The breaker may take the form of an ordinary series wound contactor with provision for closing by hand or may be more of the form of an ordinary circuit breaker which is released by the falling of a weight or operation of a trip coil when the current which it is carrying falls below a predetermined value. As the battery current must fall to zero before reversing, the breaker will open *before* the reversal of a current that is already established. The underload relay, however, has no regard for polarity and will remain closed if a reverse current is established when the battery is thrown on the line. The over-load and under-load features may be combined in one breaker, which should cover all cases except throwing the battery on a slightly under excited generator. See (5).

Circuit breakers may also be obtained with a reverse current attachment; either self contained or with a separate relay; which may include an overload release if sufficiently sensitive and rapid in action, but as an actual reversal of current is necessary *before* operation, they can hardly be depended upon to prevent reversing the polarity of the generator and in some cases may remain closed on a reverse current of sufficient strength to run the generator as a motor with no load and cause a gradual discharge of the battery (case (3) above).

As a lead cell battery gives off fumes while charging that have a corrosive effect on apparatus even at a considerable distance, it is good policy to keep the various attachments down to the minimum consistent with safety and economy, and to use rugged apparatus with such protection from fumes as may be practicable.

THE BOSTON to Washington superpower survey, the Colorado River development and other projects were discussed by President Harding and his Cabinet on April 8, as a means of minimizing the effect of coal strikes in the future and also in relation to the general economic fabric of the country. According to reports the discussion was most thorough, although no definite conclusions were reached. Secretary Hoover submitted the proposition for discussion and it is said that the Cabinet intends to continue its study of the project. The superpower survey of the Atlantic Seaboard was completed about a year ago and reviewed in those pages.

The Control of Blower Motors

FACTORS TO BE CONSIDERED IN THE SELECTION OF MOTORS AND TYPE OF CONTROL FOR BLOWER SERVICE. BY HENRY G. ISSERTELL

THE CONTROL of motors for operating blowers and exhaust fans is so clearly related to the selection of the right motor characteristics for this service, that the two must be considered together. This article is devoted to the selection of motors and their controls for driving enclosed fans of the paddle wheel, centrifugal, or multi-vane type for the ventilation of buildings.

The general conditions to be met by control apparatus applying to all types are under-voltage release, under-voltage protection, overload protection, and enclosure of live parts.

Under-voltage Release.—This means that if the voltage fails, thereby shutting down the motor, the sudden restoration of voltage shall cause no damage. The motor may automatically start up again, but it must start up through its regular steps to insure keeping down the current inrush, and to prevent jarring the fan.

Under-voltage Protection.—This means that if the voltage fails, thereby shutting down the motor, the motor can only be restarted by intentional action of someone operating the controller (if manual control) or pressing the start button (if remote push button control.)

In the case of controllers for variable speed, a.c., two or three-phase, slip-ring motors, under-voltage protection is accomplished best by a magnetic main-line switch or contactor which is opened or closed by a push-button station. In such motors the speed control is obtained by resistance in the rotor or secondary circuit which is entirely independent of the primary circuit. It is this primary circuit which must be closed to start the motor, and opened to stop the motor; therefore, fitting the speed-controlling handle with a spring return and holding coil, as in d.c. hand starter or controller, would require a multiplicity of extra and insulated contact segments which would produce a very complicated and expensive control handle.

Overload Protection.—Underwriters' requirements in most sections of the country require insertion of fuses in the motor circuits or a circuit breaker, regardless of whether a separate overload relay is installed on the control panel. Hence the use of overload release is generally superfluous where overloads are of infrequent occurrence. In the case of hand-operated starters and speed regulators for d.c. circuits which have an under-voltage release magnet which holds the controller handle in place and lets it fly back to the off position in case of voltage failure, the usual overload release, which operates to open or short circuit the under-voltage coil and so let the handle fly back to the off position, is usually unreliable and of little value.

In the case of controllers fitted with a magnetic main-line switch, which is the case with the larger direct current, manually-controlled panels (above 50 hp.), or with direct current, remote-controlled, push-button-operated panels, or with alternating current panels having

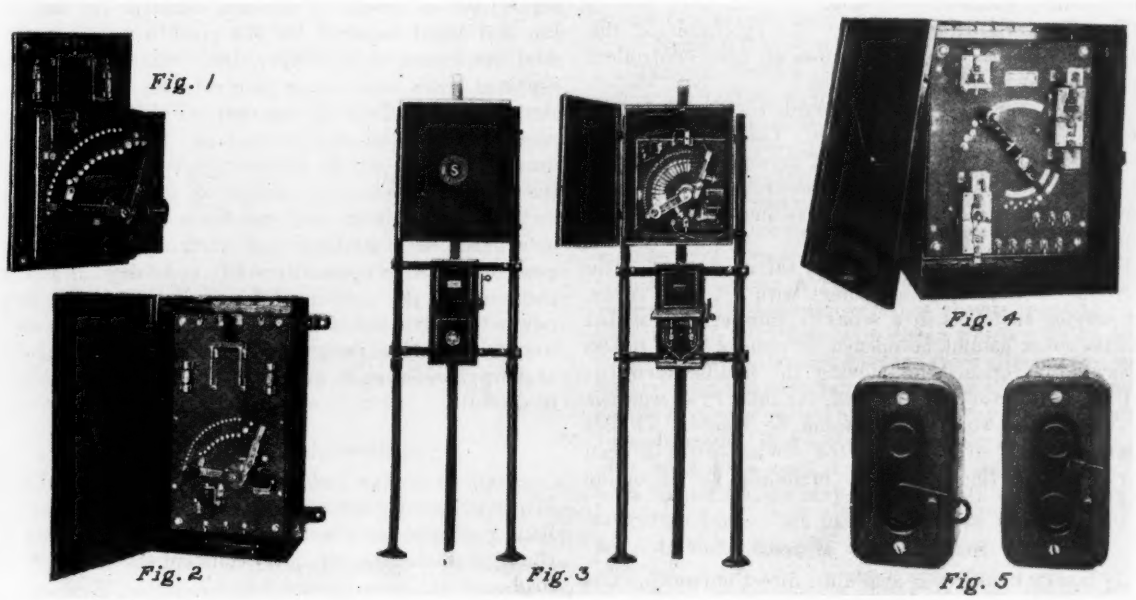


FIG. 1. OLD STYLE OPEN PANEL WITH CONTROLLER, SWITCH AND FUSES MOUNTED TOGETHER. FIG. 2. PANEL WITH CONTROLLER SEGMENTS, SWITCH AND FUSES, FLUSH MOUNTED AND ENCLOSED IN CABINET. FIG. 3. THE LATEST DEVELOPMENT IN MANUAL CONTROL. DOORS OPEN AND CLOSED. FIG. 4. DIRECT CURRENT REMOTE-CONTROL SELF-STARTING SPEED REGULATOR FOR BLOWERS, COMBINED ARMATURE AND FIELD CONTROL. FIG. 5. PUSH-BUTTON STATION FOR STARTING AND STOPPING. A LATCH CAN BE CARRIED OVER THE STOP BUTTON AND THIS LATCH HELD IN PLACE WITH A PADLOCK

low-voltage release, whether manual or remote control, a type of overload relay is available which is very reliable and can be set to close limits.

There exists considerable difference of opinion as to the relative merits of a fused switch and a circuit breaker. If no other overload protective device is installed, and if overloads are of frequent occurrence, the circuit breaker is better because it eliminates fuse renewals. If overloads are of infrequent occurrence in fan application, and if a magnetic main line switch or contactor is part of the control, the addition of an overload relay, in connection with a simple fused switch of the enclosed type, is quite as effective and less expensive to install than a circuit breaker of a type that will really meet all requirements. On alternating current, blower-motor panels especially, it makes a better combination.

Enclosure of Live Parts.—A growing appreciation of the right of both the competent electrician and the unsuspecting layman to be protected against accidental contacts with live parts of electrical apparatus, and reduction of fire risk, is bringing about a general adoption of totally enclosed controllers.

The illustrations given show the evolution of the enclosed controller. Figure 1 shows an open controller. The service switch is also exposed.

Figure 2 shows a controller mounted with switch and fuses and all mounted in a cabinet. This has been until recently looked upon as an ideal arrangement. However, when the door is open, the controller is alive and even when the switch is pulled, the incoming line terminals are alive.

Figure 3 shows the ultimate in safety devices. The controller is in a separate cabinet with a locked cover. The service switch is in a separate cabinet so designed that its cover cannot be opened to remove fuses unless the switch is opened by moving the handle forward; and when the fuse cover is open, the only live terminals are at the top where they cannot be reached without unscrewing the cover. When the service switch is open every part of the controller, including the incoming leads, is dead.

Selection of Motors

If direct current is available, direct current motors will inevitably be used. If alternating current is available, alternating current motors may be used, or a motor generator or rotary converter installed and direct current motors used. Frequently on alternating current circuits, both types are employed; direct current motors on the variable-speed blowers and alternating current motors on the constant-speed blowers and on pumps.

Motors, either alternating current or direct current, may be of the open or semi-enclosed type. There is an increasing tendency towards the latter. Open motors are, however, entirely satisfactory in most cases and, located as they are in remote and seldom-reached portions of buildings and well protected from the weather, the fire or personal injury risk is very slight, and the extra cost of semi-enclosed motors, including the cost of the larger frames frequently needed because of the restricted circulation of air through the motors, is seldom justified. Totally enclosed motors would seem never to be justified for such applications, though of course, in the case of disk fans where the motor is directly in the air stream, and hence subject to damage from foreign particles and moisture, enclosed motors are necessary.

The question as to the selection of 40 and 50-deg. motors often arises. There is a good deal of confusion existing in the minds of many engineers on this topic. So far as the ability of the motor windings and other parts to stand a temperature of 50 deg. C. above the temperature of the surrounding atmosphere (usually taken at 25 deg. C. or 77 deg. F.) as compared with 40 deg. C. is concerned, it may be said that 50 deg. C. is well below safe limits for ordinary insulation and therefore a 50 deg. motor is just as suitable for fan service as a 40 deg. motor and is usually less costly and more efficient.

This distinction is really one of overload capacity. Most commercial 40-deg. motors will stand a continuous overload of moderate amount in which case they virtually become 50 deg. motors.

Horsepower Determination

Now it is ordinarily customary to take the brake horsepower as given by the fan builders for the size fan and speed required for the given air delivery and duct resistance, this being a list value obtained by repeated trials, and add a safety factor for contingencies. This is usually 25 per cent. This factor in most cases is more than ample, especially as the figures are usually rounded out to the next highest. Thus assume the fan table gives 11 hp., adding 25 per cent gives 13.75 hp. and the engineer may call for a 15-hp. motor. To insist, then, on a 40-deg. motor, virtually means a motor good for about 18 hp. continuously at 50 deg., or a safety factor of 63 per cent over the theoretical brake horsepower—surely this is a wide margin. Such a motor would be likely anyway to run a good part of the time at low speeds and greatly underloaded and hence inefficiently.

Direct-Current Motors

Direct-current motors should be of the shunt type. If compounded windings are used, they are for stabilizing purposes on a weakened field and the motor has shunt characteristics or fairly constant speed at different loads.

Whether direct current motors for fans are of the commutating-pole type or not depends rather on the individual design than on the requirements of the application. The larger motors will be practically always of the commutating-pole type whether for constant or variable speed.

Speed Control

In the case of direct current, variable-speed motors, the method of varying the speed demands attention. The question of method involves the size of the motor, the amount of speed control desired, per cent of time operated at low speeds, and the cost of power. The normal speed of a direct current motor in the language of the designer is the speed for which it is designed to run under full load, without resistance in either armature or field circuit. The speed may be reduced below normal by resistance in the armature circuit down to ½ of normal speed, or it may be increased by inserting resistance in the field circuit. The amount of this

increase varies, but for fan work the maximum is usually 1½ to 2 times the normal speed.

When a motor speed is reduced by armature resistance, some power is wasted in the resistance and the motor consumes more power than is actually needed to run the fan and for the unavoidable or fixed motor losses. This fact has very properly led most engineers to specify field control on direct current motors. But it is quite possible to overdo this.

The power required to drive a fan varies with the cube of the speed. At ½ maximum speed, the power required is only ⅛ minimum. Therefore, the power wasted in driving fans at low speeds on armature control is very little. For these reasons, the use of field control should never be carried beyond the point where the saving by elimination of the power wasted in the resistance is offset by reduced motor efficiency resulting from a larger motor frame size and by increased interest charges due to greater first cost.

There is also involved the first cost of the controller. This is greater for armature control or for combined armature and field control in the larger sizes than for straight field control, but the increase in motor cost for all field control is greater than the increase in controller cost for combined armature and field control.

It is impossible to give rules which cover all cases, but the following are representative of a number of conditions: under 5 hp. use all armature control unless cost of current is high (over 3½ cents per kw.-hr.) and the motor is to operate practically all the time at low speeds; above 5 hp., use all field control if the total speed range is from a maximum fan speed down to 2/3 of maximum. (This means 50 per cent increase over motor *normal* speed by field.) As the decrease from maximum diminishes, the field-control motor more closely approaches the armature-control motor in cost, and on the other hand, the loss of power in resistance if armature control is used diminishes.

Alternating-Current Supply

Where alternating current supply is available, the question comes up as to whether to use alternating current motors or to put in a motor-generator set and use direct current motors. If the number of motors is small, or if the individual horsepowers are low, or if constant speed is acceptable, there is no question but that alternating current motors should be used.

In the case of larger buildings needing from 10 to 30 fans, taking from 10 to 50 hp. and requiring variable speed, the use of a motor-generator set may well be considered. All elements have to be considered in each case; the overall cost, interest on the cost, overall efficiency, and the cost of power. The losses in a motor generator are from 20 to 30 per cent at average working conditions, and an equivalent saving by using direct current motors with field control over alternating current motors with armature control must be realized to offset this. A rotary converter will usually be preferred to a motor generator set if it is possible to use alternating current for the lights, and constant-speed machinery. The somewhat decreased flexibility of voltage adjustment is offset by higher efficiency (losses 10 to 15 per cent instead of 20 to 30 per cent), as compared with a motor-generator set.

Alternating-Current Motors

The so-called multi-speed, alternating current motor is frequently pointed to as a means of obtaining efficient operation without waste of power on alternating current circuits. The objection to such motors is the lack of flexibility.

A type of motor which is rapidly coming into use is the commutator type, alternating current, brush-shifting motor. In this motor the speed is varied by shifting the brushes. When the speed is reduced, there is no waste of current in resistance. This type of motor is therefore more efficient at low speeds than slip-ring motors, and is nearly as efficient as direct current motors with field control. Any number of speeds can be obtained and the flexibility is therefore as great as a direct current or alternating current slip-ring motor and much greater than the alternating current multi-speed motor.

With the larger motors, either hand control or automatic control is possible. With automatic control a small pilot motor is mounted on the motor and geared to the brush rigging. This pilot motor is controlled from a remote push-button station from which any speed can be obtained.

Remote Control for Variable-Speed Motors

Remote control for variable-speed fan motors has many advantages over manual control and may in time come to be generally applied as the standard method, with manual control confined only to a few of the smaller and simpler installations.

A typical remote-control installation, whether for direct current motors or alternating current slip-ring motors, will consist of an automatic, self-starting controller containing a handle or switch arm which can be set to any desired operating speed, the whole self-contained in a cabinet with cover which may be locked to prevent unauthorized persons from altering the speed. Safety requirements will dictate the use of a separate, enclosed service switch and fuses. Figure 4 shows such an equipment. A push-button station located at a suitable point gives control of starting and stopping. The push-button station may be fitted with a lock to prevent operation by anyone except those in possession of the key.—General Electric Review.

Work on the development of new types of coal sampling apparatus is being done at the Washington, D. C., office of the Bureau of Mines, under the direction of O. P. Hood, chief mechanical engineer. The practicability of coal inspection on a large scale depends upon the development of sampling devices which can obtain a true representative sample with the least possible interference with transportation methods. This means the development of apparatus somewhat comparable with apparatus used for loading and unloading coal. A machine has been developed which will drill a 6-in. hole vertically through coal carried in a car and abstract the cuttings. Complete detailed plans have been made for a single sampler adapted to take samples from truck loads at the Government Fuel Yard. General plans have also been developed for a multiple sampler adapted to take samples from open top cars in a railroad train without distributing the train or the unloading coal. Only the reduced laboratory sample is to be taken from the sampler.

Power Plant Operates While Building Burns

HEROIC SENSE OF DUTY WHICH KEPT ENGINEERS AT THEIR POST SAVES POWER PLANT FROM DESTRUCTION

SHORTLY AFTER midnight on March 15, 1922, there started in Chicago, one of the most spectacular and destructive fires that the city has witnessed in recent years. An entire city block adjacent to the new Burlington office building was swept away—not a wall was left standing. How fireproof the building in itself was (with fire originating within the structure) will be realized when one considers that while the ninth to fifteenth floors inclusive were a mass of fire, the sixteenth floor, which had no windows through which the fire could enter from the outside, was entirely intact and no damage whatsoever was done to machinery or records located there. The solid construction of this floor, similarly to the others, prevented the penetration of the fire from below. Although the temperature on this floor must have been rather high for human comfort, it is a peculiar fact that the roof would have afforded a perfectly safe shelter for anyone trapped above the burning section.

CHIEF ENGINEER, J. O. BATZER

All Chicago knows of that fire. The remarkable manner in which the big steel sky scraper resisted the ravages of the flames was a matter of interest to the thousands of workers who daily place their faith in the safety of similarly constructed buildings. The daily press published striking accounts of the disaster.

What the public does not know, however, and what the newspapers failed to accentuate in their write-ups, was the part played by the engine room crew. Little was said of how those men risked their lives in the subbasement of that blazing structure in order that the equipment installed there might be saved; for if it had not been for the heroic sense of duty which kept those men at their posts throughout the whole of the conflagration, not only would the costly power plant have been destroyed, but the building itself would have suffered far greater damage than actually was the case.

In the second basement, 32 ft. below the street level, they remained, undaunted at their posts and while the structure above was transformed into a red hot furnace, they kept the engine room from being flooded by the tons of water which poured into it from above.

Their bravery and resourcefulnes cannot be too highly commended and this incident illustrated another angle of the power plant engineer's job which too often goes unnoticed.

On the night of the fire, the chief engineer, J. O. Batzer was at home. The night engineer, Joseph Knecht and the night fireman, Joe Nohava, were on duty. Shortly before two o'clock in the morning Mr. Batzer was called to the telephone, and found the night engineer at the other end of the wire.

"The building is on fire," he reported. "Come down as soon as possible." That was all. When the chief attempted to gain further particulars, the connection was broken.

Dressing hurriedly, he quickly made his way to the garage in the rear of his house where he kept his car, and 15 or 20 min. later arrived at the scene of the fire. One look at the burning structure was sufficient to acquaint him with the seriousness of the situation. The fourteenth and fifteenth floors were already glowing furnaces.

He dashed through the main entrance of the building and down the stairway into the engine room two floors below where he found his assistant waiting for him.

"What pumps have you got going?" was Batzer's first question.

"All of them," replied Knecht, "but I can't get enough water."

The fire system in the Burlington building is as shown in Fig. 2. A 6-in. line from the city water main feeds into a 1500-gal. surge tank. Three pumps arranged as indicated take suction from this surge tank and discharge to two house service tanks or to the fire mains direct. The 6-in. city line, however, was entirely too small to furnish enough water for the three pumps with so many fire engines drawing water and the result of this unfortunate condition was that when the chief engineer reached the pumps, he found them all pounding away badly and the suction pressure gage was down to zero. Seeing the futility of trying to keep all three in operation, he shut two of them off, so as to give the remaining one enough water to operate satisfactorily.

The amount of water furnished by this one pump, however, was greatly below that necessary to effect any helpful influence. The efforts in this direction were therefore limited, and the attention was directed to the switchboard.

He began to throw in all the feeder switches to the lighting system, in order to give the firemen on the upper floors as much light as possible. And then the fireworks began! Bang, sputter—bang! Every time, one of the switches was thrown in, the circuit breaker would open with a flash or the fuses would blow. The fire already had gained considerable headway and many of the circuits on the upper floors were burned off; others were short circuited. The chief, nevertheless, threw in as many switches as would stay closed, and in some cases, by holding the breaker, was able to burn some of the "shorts" open.

From that time on, the switchboard was the center of a pyrotechnic display of no small proportions. Each time the fire reached a new circuit on the upper floors, a short circuit would occur. This action imposed considerable hardship upon the generator, for each time a short occurred, the machine would groan and labor in a manner that would not have been tolerated under ordinary circumstances. But these were not ordinary cir-

cumstances by any means—they were very much extraordinary.

In the meantime other things were happening. One, was the falling of the window weights from the burning window frames in the upper stories of the building. The Burlington building, although modern in every other respect, unfortunately, was fitted with wooden window frames. As these frames burned away, the two heavy window counterweights would be precipitated into the street below where they struck with tremendous force. It was like a bombardment from the air—the weights came down with astonishing swiftness and regularity. Hurtling from a height of anywhere from eight to fifteen stories, they possessed sufficient force to crash clear through the heavy cement sidewalk.

The only part of the engine room which is directly under the sidewalk is an area about 15 ft. square, directly above the surge tank and city water connection previously referred to. This area was fitted with prismatic sidewalk lights, and was, of course, much more vulnerable than the solid cement. It is, therefore, almost needless to state that this section of sidewalk did not stand up long under the terrific bombardment of window weights. They tore through as though through so much paper. This, of course, left the surge tank and associated piping unprotected, and Batzer was, for a time, worried in regard to the safety of this equipment.

As fortune would have it, however, none of the weights struck the apparatus squarely, although stripping it of covering, much of the rubbish which had come down was beginning to accumulate over the tank as well as in the engine room, and this probably broke the fall of the weights somewhat.

The steamer connection to the building's fire system is located near this point and on two occasions the firemen's hose connections were severed by the falling weights. The severed hose would then point through the hole in the sidewalk and send a 2½-in. stream of water directly down into the engine room until the firemen could be communicated with to stop the engine feeding this line of hose.

Up to this time not much water had entered the engine room, but now it began to pour down in torrents. Things commenced to look extremely serious and the chief engineer was doubtful whether it would be worth while to remain. So he put it up to his assistants.

"Men," he said, "this is a serious situation and I won't ask any man to remain here unless he wishes to do so of his own accord. There is danger and I'm not certain whether we will be able to save the plant. As you know, boys, the current has not been off of that switchboard for a moment since it was first put there ten years ago, but this may spoil our record. If you decide to stay, however, I'll stay here with you."

"We'll stay," was the unanimous reply, and then the work began in earnest.

The first thing Batzer did, after they had decided to remain, was to provide a means of possible escape. Although he had considerable faith in the steel construction of the building, he was afraid that the great quantity of debris which was accumulating would in time entirely block all chance of escape from the engine room. The water also was rising rapidly and there was danger of the entire engine room being flooded. Naturally, he had no desire to be trapped.

He, therefore, made his way to the first floor, two flights up with pick axe and selected a place to cut away one of the windows through which escape from the building might be made in case of emergency. It required considerable effort, however, to mount the stairway leading up to the first floor. Tons upon tons of water were pouring down from above and they transformed the narrow passageway into a turbulent waterfall. The water came down the stairs almost knee deep and it was only by pulling himself up on the hand rails with main effort that the chief was able to make any headway.

The water entering the engine room was finding its way into a sort of tunnel which is formed by the space between the engine foundations. This tunnel contains no apparatus except the generator rheostats, exhaust piping and the conduit leads from the generator to the switchboard. It is fitted with a number of drains which empty into a sump from which, in turn, the water is pumped out by means of two vertical electrically driven pumps.

FIG. 1. THE BURLINGTON BUILDING FIRE

The drains, however, were entirely inadequate to handle the enormous quantity of water which was coming down; furthermore, a number of them clogged up with rubbish.

In the engine room water was also commencing to leak through the ceiling loosening covering and plaster. To prevent it from damaging the equipment it was decided to cover everything with tarpaulins. The tarpaulins were stored in the first basement, so in order to get at them it was again necessary to brave the force of the miniature Niagara at the stairway. Once on the floor above new trouble was encountered in the form of fire at this point. This, it seems, had been started, by embers coming down the main pipe shaft which runs vertically through the building. This fire, first, had to be extinguished.

These tarpaulins in addition to a liberal supply of others from the fire insurance patrol were then brought to the engine room and all machinery not in actual operation covered with them and a canopy built around the generators in operation. The switchboard was also covered, but due to the circuit breakers opening up whenever a new short circuit occurred, the canvas covering

would catch fire. These would have to be extinguished at regular intervals. The reader need not ask what the engine room crew did in their spare time!

All the drainage pumps were electrically driven. It was therefore absolutely essential that the generator be kept running. Had the generator failed, the pumps would have stopped and the engine room flooded.

About 6:30 a. m. it was noticed that the water was entering much faster than it was being pumped out. Hundreds of streams of water had been pouring into the burning structure above all night and, by this time, it was thoroughly saturated. Water swept in through all openings. The drains in the flywheel pit of the generating unit were clogged and the big flywheel began to swirl water in all directions. The tunnel underneath the engine room was rapidly filling and it was seen that it would not be long until the water would reach the generator rheostats. Something had to be done, and there was no time to be lost doing it.

It was then that Batzer thought of the abandoned water main 40 ft. below the engine room floor.

Some 20 yr. ago, it seems, a 7-ft. city water tunnel had been constructed across the site now occupied by the Burlington building. It had long since been abandoned, however, and when the new Burlington building

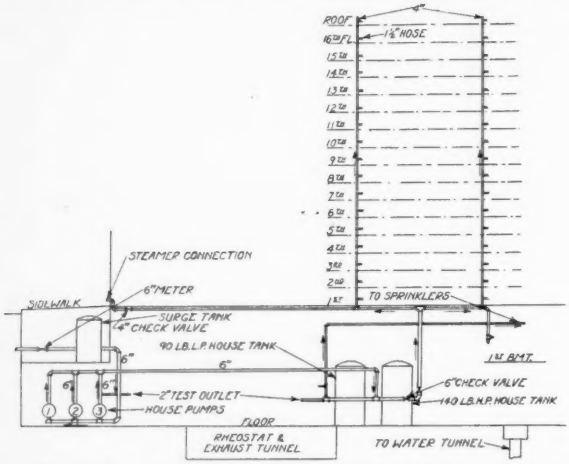


FIG. 2. DIAGRAM OF FIRE SYSTEM, BURLINGTON BUILDING

was erected, it had been bricked up at both building lines. The tunnel thus formed a sort of reservoir, and, the chief engineer had for some time past used it as a place for storing water for use in case the city supply should temporarily fail. A 500-gal. per min. electrically driven pump had been installed to withdraw the water from this tunnel, either for plant service or discharge to sewer.

It was obvious that if the water from the tunnel below the engine room floor could be drained into this abandoned tunnel 40 ft. lower, the 500 gal, per min. pump would then be able to discharge the water into the sewer. But, how to get it into this tunnel? That was the question.

"Well, why not syphon it in?" finally thought Batzer, and this was an excellent plan except for one thing —he had no syphon.

There was some pipe on hand, however, so he decided to make up one. But this was no simple task and required their concentrated efforts for over an hour. It so happened that there was installed in the sidewalk elevator shaft, a 2-in. syphon which is occasionally used to remove water that collects in this shaft. This syphon could be used to good advantage now, but the problem was to remove it from the shaft. The latter was filled with about 6 ft. of water and in order to disconnect the syphon one would have to dive down below the water.

This, the first assistant engineer, James Kelly volunteered to do. It was not the pleasantest sort of a job one can imagine. The reader must remember that this occurred on the 15th of March and the night was by no means warm. Then try to imagine what a pleasant task James Kelly had in that dark, dank elevator shaft, almost up to his neck in cold, dirty water, with the glare from the fire visible through a large opening overhead in the steel trap door on the sidewalk made by one of the "shells" and momentarily expecting another in the same spot. For 20 min. he labored, but finally won out and succeeded in disconnecting the syphon.

Little more remains to be told. By 7:30 a. m. three syphons were in operation and the water in the tunnel below the engine room was rapidly emptying into the abandoned water tunnel 40 ft. lower. The 500-gal. pump was in action, and the power plant was saved.

Although the building still stood, it was a gaunt skeleton from the eighth floor up. The white tile exterior was begrimed and blackened, and scarcely a window pane was left intact. Tens of thousands of valuable records belonging to the Burlington Railroad had been utterly destroyed. The loss was appalling.

Below the eighth floor, however, the building was in fairly good condition, and 24 hr. after the fire, the power plant was giving service in this part of the building. As all vertical feeder conduits, steam and water pipes had been practically burned off above this point, most of them were cut off, the ends of the conductors taped and caps put on the supply pipes. In this manner they could be used to distribute current, steam and water below the eighth floor.

Had the engine room crew not remained on the job during the fire, it is doubtful whether service would have been re-established even now, for there would have been no power plant to supply such service, and the building itself might have suffered far greater damage than it did.

UNDER ORDINARY conditions, the ignition temperature of a fuel is less important than the maintenance of combustion. No matter how large the mass of fuel may be, whether it is in a blast furnace, under a boiler, or in an ordinary household furnace, the origin of the heat necessary to raise this fuel to the ignition temperature is in the kindling which starts the fire.

It is, however, in connection with the storing of coal in piles that the ignition temperature takes on a real significance. Coal is actually burning at all times and even at low temperatures. If the heat thus produced is sufficiently confined and is supplied to the coal at the proper rate the temperature of the interior of the mass will rise. As the temperature rises the rate of combustion also rises and after a certain safe temperature is passed the process goes on quite rapidly until burning or flame results. Bulletin No. 128 of the Engineering Experiment Station of the University of Illinois, "The Ignition Temperature of Coal," by R. W. Arms, makes a study of this problem.

Dashpot Troubles

RECENTLY I have come across a few cases of dashpot trouble which may be of interest to other engineers.

The first case was when a dashpot was sluggish, did not drop properly. The dashpot was taken out, and with valve on suction chamber closed, the plunger was pulled out easily, indicating poor vacuum. On the bottom of this pot was a plate held by four capscrews. The plate was removed and the gasket looked to be in good condition. However, a new gasket was made, and the plate fastened on again. The plunger was then tried as before but could not be pulled out; the vacuum was O. K. The air leak was through the old gasket. The pot has given no trouble since.

In another case where a dashpot did not operate properly the check valve was examined and found to

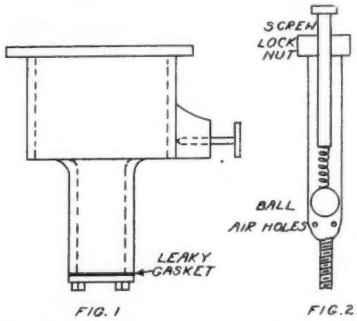


FIG. 1. DASHPOT SHOWING LOCATION OF LEAKY GASKET
FIG. 2. CHECK VALVE WHICH GAVE TROUBLE

be in good order. After considerable trouble hunting the dashpot was removed and the trouble was at once seen. There was a second check valve on the pot which was not seen before, as the pot hung below the base plate of the cylinder. The lock nut on the screw of this second check had loosened and in course of time the screw had backed out, causing the spring and ball of the check to bounce out. These were found lying beneath the pot. See sketch of check.

Another case was when the steam valve was bound between the steam bracket and the plate on opposite side of cylinder. A thicker gasket was placed on the plate, giving the necessary clearance endwise, which ended this trouble.

Still another case: An engine had been in operation several years and suddenly developed a bad case of bucking. The engineer took off all the piping and the check valve apart, cleaned all out thoroughly, but the pot still did not work. It was finally found that the valve stem was not properly lubricated, had become dry and worked hard in the bearing in the valve bracket. The oil cup was taken off and a liberal supply of cylinder oil was used. In a few minutes the pot was working O. K., or rather the valve stem was, and the pot worked fine, closing the steam valve properly.

A dashpot which does not work is a source of trouble and worry to the engineer; often it is some little thing which causes the trouble, but sometimes it is difficult to find out what that is. When an engine has a light load, with a high steam pressure, there is but little lift to a pot, especially where double ported steam valves are used, and there is more or less pounding of the dashpots; that is, the plungers are forced down by the gearing. The valves are slow in closing and often do not close perfectly, causing the steam to blow through. It is well then to throttle the steam somewhat, or to carry a lower pressure. Either of these will give a longer cutoff and will give the pots more lift. Sometimes a shot or two of cylinder oil with a hand pump helps matters and also a change of cylinder oil is sometimes beneficial.

TOM JONES.

Damper Position Requires Special Chain Arrangement

AT ONE TIME I installed a steam-operated damper regulator; when about to arrange the chain from the regulator to the damper handle, I found that I could not run this in a vertical and horizontal position as I

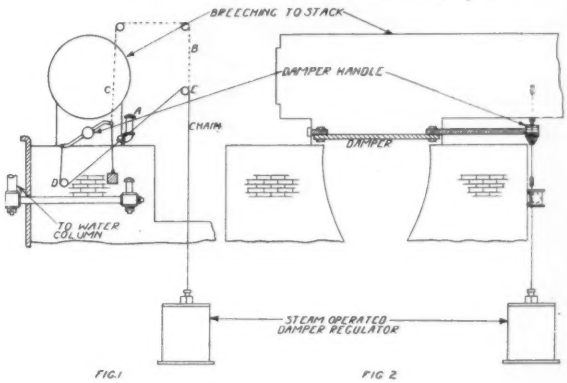


FIG. 1. END VIEW OF DAMPER SHOWING CHAIN ARRANGEMENT
FIG. 2. SECTION THROUGH BREECHING SHOWING DAMPER LOCATION

had at first intended, because the breeching leading from the boiler to the brick stack was in the way. As shown in Fig. 1 at B, C, dotted lines, I could not make the damper handle longer due to the fact that a number of pipes were in the way, one of which was the steam water column connection as shown at A, and also one of the buck staves was in the way. As I could not change these I had to find some other way to arrange the chain.

In thinking the matter over for some time, I hit upon the idea to arrange the chain as shown by the full lines leading from the damper regulator to the damper handle. This was done by fastening a pulley to the lower water column connection as shown at D nearly in line with one end of the damper handle; then another pulley as shown at E was fastened to a pipe on top of the boiler which was most convenient to bring the chain in line with the chain holder on the rod of the damper regulator piston. After the chain was adjusted and all ready, the regulator was put in operation and worked nicely. A side view of the stack, breeching and how the damper and handle rod is located is shown in Fig. 2.

H. A. JAHNKE.

Valve Yoke Repair

I SUBMIT the enclosed picture of a valve yoke repair, but am not recommending its use. I have heard an engineer argue that there is no God. But when I run into something like this, I would be convinced that there is a Providence that takes care of some so-called engineers, at least.

When the present management took charge of this plant, this 5-in. valve was the main boiler-to-header

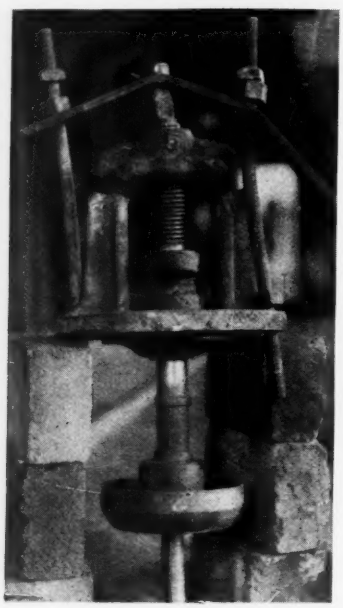


PHOTO OF VALVE YOKE AS REPAIRED

valve. It was in exactly the condition the picture shows. The yoke had been broken. The iron across the top is ½ in. thick, 2 in. wide, of a poor grade of wrought iron. The bolts were galvanized ⅝ in. diameter, cross arm spacing bolts of wrought iron. The valve was 5-in. in diameter and located between the main header and a 200-hp. boiler carrying 125 lb. steam pressure.

When the boiler was "cut in" or "cut out," it was accomplished by unscrewing the top nuts on the bolts. If you will figure the area of the seat and base your calculation on 125 lb. steam pressure, you can imagine what could have easily taken place when the valve started opening. It is needless to say that a new yoke was ordered at once and the valve put in first-class shape. How long it had been used this way, nobody knows, and if anyone knows who "repaired" it this way, they will not admit it.

Just another reason for license laws and thorough examination of men as to their knowledge of the action of steam.

H. A. CRANFORD.

Stresses in Pipe Bends

SUPPLEMENTING my letter in the April 15 number of Power Plant Engineering, I have obtained a copy of the Valve World, October, 1915, and find that specific mention is made of extra strong pipe. In fact, it was so special and was apparently considered so important by the manufacturers that it was set in italics and these italics are the only ones on the page. This indicates to the writer that the manufacturers knew what they were talking about and that there was no question about it in their minds. The italics are as follows:

"The results obtained with extra strong expansion 'U' bends check closely with corresponding tests of full weight pipe. On the basis of these tests, we recommend the same expansion value for any shape extra strong pipe bend as for a corresponding full weight pipe bend."

In connection with pipe bends, there is sometimes a question in the mind of the engineer ordering the bends as to the length of the straight ends or tangent ends so that threads can be cut or flanges attached or so that ends will not be "out of true." A safe rule to follow is this: "Always allow straight ends on each end equal to the pipe diameter plus at least 2 in. For smaller diameters, this rule gives very close results, while for large diameters, 2 in. is more than is necessary; but throughout the entire range of pipe sizes, it is on the side of safety"

W. F. SCHAPHORST.

Keep and Analyze Records

ONE OF Power Plant Engineering slogans is to keep and analyze operating records in power plants. This can mean and might mean recording charts. Used as they are intended to be used, the recording meters and instruments in power plants are a very important part of the equipment. Like a good workman, if they are mis-used or ill-used, or carefully neglected, they are apt to be of small if any value; in fact, just the opposite. All that is necessary to prove the value of a recording steam pressure gage is to examine a chart and the amount of coal consumed on a run right after the boiler and tubes have been cleaned and another chart taken when the cleaning is due or overdue. The difference in the chart line and in the quantities of coal used will be worth consideration. To listen to some talkers, it might be inferred that the only use a steam pressure recorder can be put to is to keep tab on the firemen.

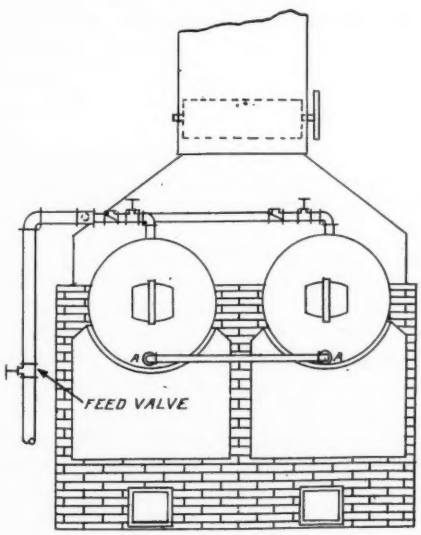
As Power Plant Engineering advises, do a little analyzing and perhaps it will indicate to you that the boiler cleaners, internal and external, need a bit of attention. Some managers are too ready to condemn the fireman when a poor chart is turned in, when he fails to deliver a good chart with the minimum amount of coal used. He should first do a little analyzing. If a chief engineer knows his business, this is what he will do. Instead of bullyragging the fireman he should ask him if he has any idea to advance why the chart should be

below normal. Some of the present-day firemen know as much and perhaps a bit more than some of the chiefs. The dishonest power plant employe no doubt exists; I believe their number is not great. Such a man can, with a small amount of trouble, so alter a steam pressure recorder that almost any kind of a chart he desires can be turned out. It has been done, and perhaps is being done.

When any certain man whose steam charts have seldom been above the average begins turning in nearly perfect ones, it might pay to do a bit of inspecting before holding him up as a model. The V notch and other meters have often been fooled by a power plant crook. Whenever a man is detected interfering with the proper operation of recording instruments or equipment, he should be discharged. JAMES E. NOBLE.

Making One Boiler Out of Two

IN A MANUFACTURING building of which I had charge rather an interesting question arose regarding the number of boilers installed there. The steam-generating plant consisted of three 300-hp. water-tube units, each unit composed of two drums with their accompanying sections of tubes, safety valve, steam-gage, water column, and blowoff pipe. The two sections were in one setting with no dividing wall between,



SKETCH SHOWING BOILER INSTALLATION

the baffles continuing through from one side wall to the other, while one furnace, bridge-wall, damper and stop valve served both sections. I considered each unit as one boiler, as did two different insurance companies; but the City Bureau of Steam Boiler Inspection insisted that we had six boilers and charged accordingly.

We experienced some difficulty in maintaining an equal water level in the gage glasses of the two sections of a unit, the fluctuations being influenced by the condition of the fire under that section. The rear ends of the drums were already tapped for 2-in. pipe and plugged, as shown at A, A in the sketch.

A cross-connection of extra heavy pipe and fittings was finally made between the drums, a change which gave us an equal water-level, at all times. A conference was then held, between the chief of the bureau, a representative of the insurance company, a consulting engineer and myself. After considerable discussion the chief was finally convinced that we had only three boilers and ordered the numbers changed. The saving amounted to only $6 a year, but $6 is $6 and, at that time, would buy two tons of coal. M. M. BROWN.

Sewer Keel Condenser

HOW MANY of us ever realize the additional horsepower available in the water running through our city sewerage each day and what an enormous amount of coal would be saved if a limited number of plants would use trombone coils connected inside the sewer with cool-

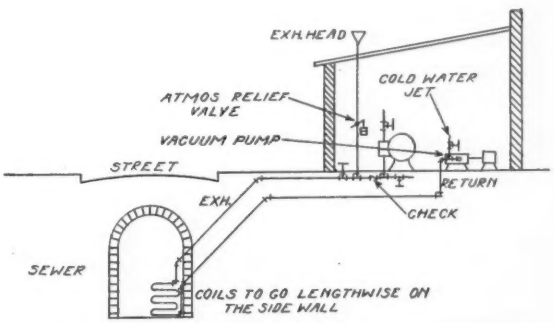


DIAGRAM SHOWING SUGGESTED SEWER KEEL CONDENSER

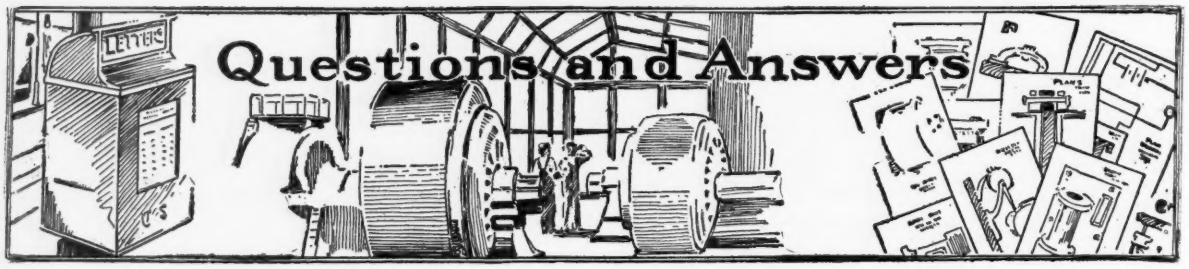
ing surface sufficient to condense each engine's exhaust, and the additional condensing effect of a cold water jet entering the vacuum pump suction as shown.

It looks reasonable to me that such a condenser built on the principle of a tug boat keel condenser with a surplus of cooling surface to allow for the rising temperature of the sewage water would pay big dividends. The detrimental effect of cylinder oil would have to be closely watched if the condensate is used. The drawing clearly shows the scheme. A. C. WALDRON.

Removing Boiler Tubes

UPON TAKING charge of a horizontal water tube boiler I found six tubes in the bottom row curved badly and I decided to take them out.

This boiler had horizontal baffles and the lower one lay on the bottom tubes. Upon inquiring as to method and tools used at this place for retubing I was told that a hammer and cold-chisel were formerly used. I asked for the loan of a burning torch and got it. We burned the tubes off about 4 in. from each header and took them out through the fire door. As the tubes are too close to work the torch around them, we burned square holes in the bottom side large enough to insert the torch, then, burning up on the inside of the tube, it is quickly cut off. After the tube is cut off, we put the torch in the header and ripped the short pieces of tube which were left in the header when the tube was cut off. In this way we were able to remove six tubes and replace three in about 5 hr. Later I removed some tubes from a B. & W. in the same way except that I made four cuts instead of two on each tube. C. F. BAIR.



How Should High Pressure Flanges Be Drawn Up?

I WOULD like to have some of the readers of Power Plant Engineering tell me what is the proper way to draw up flange bolts on high pressure headers and boiler feed pipes. In fitting a 2500-kw. plant my main trouble is in getting the gaskets to hold. I have followed up flanges every day for a week, and they give as much trouble as one that is drawn up tight and never touched again. O. L. W.

What Causes Quick Return Action on a Feed Pump?

NOT LONG ago I was up for examination for an engineer's license. Among the questions asked by the examiner was one concerning a double-acting simplex straight line pump, which I was unable to answer in full.

Suppose such a pump which functioned normally on the forward stroke, but returned with a quick motion, the whole action being somewhat similar to that of a quick return planing machine. What is the cause of this trouble? My answer was that one of the valves was gone, but I was unable to say which one. The opinions of readers on this subject would be appreciated.

P. B.

Effect of Counterbore

REFERRING TO F. R. B.'s question on the effect of counterbore, I will say that I have had nearly the same experience. All causes of knocking are not by any means to be blamed on a lack of counterbore. Such a thing as a piston jump, which might occur after the cylinder had been rebored leaving too much clearance unless thicker rings were used, might cause the knock. A knock might also be caused by the piston being loose on the rod, due to an ill fitting taper. Play in the crosshead may be transferred to the piston so that the noise would appear to come from that source.

I mention these unusual knocks because F. R. B. states that the knocking commenced only 30 min. after starting up.

A 1/32-in. ring lap is too small and I would rather use 1/16-in. If the overlap is not sufficient a shoulder will be worn, perhaps not at the bottom where the piston would wear it off, but surely, at the top. Such a shoulder is dangerous and may under certain conditions result in a wreck. The wrist pin and connecting rod being loose, the piston may jam and seize on the shoulder and cause the snapping off of the connecting rod bolts. This condition is more common in gas than in steam engine practice.

A fair amount of counterbore is necessary but it must be in proportion to the size of the cylinder. The same can be said of the cross-head shoe and guides; in days past they figured it an economy in oil if there were no counterbore, as the shoe or piston was not wiping off oil at the end of each stroke, but modern design and practice are in favor of counterbore, taking the question from every point of view. CHAS. LABBE.

Cause of Leaky Tubes

REFERRING TO W. C. B.'s question in your issue of May 1, on page 487, in which he states that his boiler is forced above its rated capacity and that great care is exercised to avoid strains due to cooling at all times, he failed to state at what temperature or at what point the feed water enters the boiler. Assuming that the feed water enters the boiler at some point below the water line close to the rear end, near the tubes, and that the temperature of the feed water was about 100 deg. F., this would constitute good cause for the tubes to leak, especially when the boiler is operated above its rated capacity. The leaks would be caused through unequal temperature of the feed water and the water already in the boiler.

If W. C. B. is feeding through the blowoff pipe at the rear end, he is following a good practice. The feed water would be heated in the combustion chamber before it enters the boiler; but when a boiler is operated at its full capacity and much water is evaporated, the feed water is entering so fast through the blowoff that it does not have time to be heated to a high degree. A good way to feed a boiler of this type is to run the feed pipe down to about the center of the boiler between the tubes and connect a tee at the extreme end and screw a nipple into each end of the tee, extending about 8-in. at each end. This pipe should be examined when the boiler is cooled down to be cleaned because corrosion is liable to set in and close the outlet. To prevent an accident through this cause, a relief valve should be placed on the discharge pipe leading from the feed pump and to the boiler. In my opinion, the life of any type of boiler is prolonged by having the feed water heated to about 212 deg. on entering the boiler and if enough exhaust steam is not available, live steam should be used.

In feeding a boiler through the blowoff pipe at the rear end, care should be taken that it is covered with a larger size pipe called a sleeve or a brick work should be laid around it in such a way as to prevent the flame in the combustion chamber from coming in contact with the naked feed pipe. I remember one accident where a fireman covered a hot fire with green coal. At this particular time, he put more coal on than usual as his intention was to go up into the street to get some fresh air and by covering his fire heavy it gave him more time to rest before he returned to put on more green coal. The steam pressure, however, dropped about 20 lb. and,

of course, the boiler cooled off suddenly. In about 7 min., the fire came up to a splendid heat. The feed pump was working continually and pumping cold water through the blowoff at the rear end of the boiler and through the combustion chamber. The blowoff was naked and exposed to the high flame. The next instant the blowoff failed, bursting in two places, putting out the fire and causing the plant to be shut down. This happened, of course, through sudden and unequal temperatures. When coal was piled on the fire, the blowoff was cooled off considerably; and when the fire burned up, the temperature increased suddenly and in addition the pump was pumping cold water through the blowoff.

PATRICK MOLLOY.

EDITOR'S NOTE: It should be noted in regard to the suggestion for feeding through the blowoff that paragraph 315 of the A. S. M. E. boiler code makes the statement: "The feed water shall discharge at about three-fifths the length of a horizontal return tubular boiler from the front head (except a horizontal return tubular boiler equipped with an auxiliary feed water heating and circulating device), above the central rows of tubes, when the diameter of the boiler exceeds 36 in. The feed pipe shall be carried through the head or shell near the front end . . . and be securely fastened inside the shell above the tubes."

Combustion Temperature Determination

WILL YOU kindly inform me as to the maximum theoretical temperature obtainable in a boiler furnace; also the practical limit? What conditions affect the result?

H. T.

A. The temperature obtainable is dependent upon, 1, the nature and quality of the fuel fired, including the quantity of moisture present; 2, the nature and quantity of the products of combustion; and 3, the specific heat of the gases formed including air that has not been used.

When carbon is burned in air, the two elements combine in the proportion of 12 parts by weight of carbon with 32 parts oxygen to give 44 parts CO_2. One lb. carbon uses, therefore, $32 \div 12 = 2.67$ lb. oxygen to produce $1 + 2.67 = 3.67$ lb. CO_2. As air is composed of 77 per cent nitrogen and 23 per cent oxygen by weight, $77 \div 23 \times 2.67 = 8.9$ lb. nitrogen will be carried along through the furnace for each pound of carbon burned.

Neglecting radiation, all the heat liberated by this action will be utilized to heat the products of combustion. As the specific heat of CO_2 is 0.216 and that of nitrogen 0.244, the heat absorbed by these gases per degree F. rise in temperature is

Carbon dioxide . . . . . $3.67 \times 0.216 = 0.794$
Nitrogen . . . . . $8.9 \times 0.244 = 2.17$

2.964 B.t.u.

As the heat liberated by carbon in burning to CO_2 is 14,600 B.t.u. per lb., the temperature attainable will be $T = 14{,}600 \div 2.964 = 4920$ deg. F. above the temperature of the air. Assuming an air temperature of 70 deg., the temperature attainable would be $4920 + 70 = 4990$ deg. F.

If excess air is used more gas will have to be heated and the temperature will be lower. Assuming 100 per cent excess, the extra air will weigh $2.67 + 8.9 = 11.57$ lb. Taking the specific heat of air at 0.24, the heat absorbed per deg. rise is $11.57 \times 0.24 = 2.78$ B.t.u. The temperature attainable would then be

$T = 14{,}600 \div (2.964 + 2.78) = 2540$ deg. F. or with 70 deg. initial temperature, 2610 deg. F.

If, instead of carbon, coal is used, the problem will be complicated by having to consider hydrogen and water. The following equation will, however, give approximate results:

$T = (616 \times C + 2220 \times H - 327 \times O - 44 \times W) \div (f + 0.02 \times W + 0.18 \times H)$ where C, H, O and W are respectively the percentages of carbon, hydrogen, oxygen and moisture in the fuel, and f is the pounds of dry gas per lb. of fuel.

Radiation has a marked effect on the temperature, but it is a quantity that is difficult to determine. Nothing has been said about a time element, but the rate of combusion also has an important effect.

Massachusetts Second-Class Engineer's Examination Questions

How is leakage prevented at the heads of a boiler shell where the plates butt together at the joint?

A. A wedge called a Dutchman is driven in far enough under the shell plates to allow for calking of the plates over it. A rivet is driven in back of this wedge to hold it in place.

2. How does oil affect a Manning boiler?

A. Oil will settle on the lower tube sheet, causing it to overheat, which will start the tubes leaking. It will also settle on the furnace sheet, causing overheating and bagging between the stay bolts.

3. In a water tube boiler, what will start the nipples between the mud drum and header leaking?

A. Scale, oil, pitting, and corrosion may start a leak at this point. If a setting has settled to such an extent that the weight of the boiler is being supported by this drum, the stress will cause the nipples to leak.

4. If the compression on a Corliss engine were reduced almost to the minimum, what would be the effect on the engine?

A. The effect will first be noticeable by the action of the steam valves; they will open hard and will groan, it will be found difficult to keep them properly lubricated, and they will cut and groove the seat.

5. What is the objection to the use of a single stage turbine?

A. On a single stage turbine the rotor will have to be large and the velocity high in order to be able to utilize the steam to the best advantage. This involves mechanical difficulties in the form of reducing gears to reduce the speed to a point at which it can be conveniently used.

6. If the valve on a variable lead engine showed ¼ in. lead at each end with the governor weights out to the extreme position, what would be done to correct it?

A. Engines of this type are usually equipped with a flywheel keyed to the shaft so that there is no chance of slipping. Some makers provide an eccentric pin which can be turned to the correct position. If the wheel is held in place with set screws, the chances are that it has slipped, in which case it should be turned back until the desired lead is obtained.

F. W. R.

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The Engineer's Duty Towards Humanity

The tremendous importance of the United States as an industrial nation today is due, in a great measure, to the almost universal use of power in all lines of industry. The successful application of power to the needs of humanity has transformed this country from a barren wilderness into the world's greatest nation in a period which covers approximately a century and a half. This period dates back to 1764, the year in which James Watt invented the steam engine. It is true, we have records of a simple form of steam turbine in Nero's time, some 2000 yr. back, but we can disregard that and mark the beginning of our industrial progress from the birth of the steam engine.

Crude and inefficient as the first steam engine was, it nevertheless served to run a few pumps and grind a little flour, thus removing the burden of supplying energy from the shoulders of human beings who, heretofore, had supplied it. It gave the human being time to do other things—it gave him time to think up other uses for his engine while, in the meantime, the steam did the work.

Since that crude beginning, progress in utilizing the forces of nature to satisfy the requirements of mankind has been more or less continuous, and today the welfare and prosperity of a nation of over one hundred millions of people is absolutely dependent upon the proper and intelligent application of its power resources. Power is today the lifeblood of the world. Every throbbing dynamo in every industrial or central station plant throughout the country is doing its part, however small, to add to the wealth and welfare of the nation, for power is wealth. Power enables us to increase production, and increased production means increased wealth. The stored-up solar energy of the carboniferous age is, today, our greatest asset. Without it, production of manufactured articles would fade into nothingness. Transportation and communication as we know it would practically vanish, and our homes would be darkened.

The measure of any country's economic importance in the world today is the extent of her fuel resources, for fuel may be transformed into power. In the United States we are, therefore, fortunately situated—in the vast stores of coal and oil which we have available, lies the accumulated energy of a million years of sunshine. In these fuel resources we possess riches of incalculable worth.

The possession of these riches, however, is no reason why we should misuse or waste any of them. "These resources," as George Otis Smith says, "only makes us trustees on a larger scale and places on us the duty to pass them on to our children in first-class condition." We are entitled to use only what we need of them, but nothing more. As soon as we begin to waste any of them, we are overstepping our inherited right and are depriving our children of that which rightfully belongs to them. Our coal deposits may be enormous, but they are not unending. Three or four generations of coal consumption at the present rate will make noticeable inroads into some of our most important coal beds. There are only two things that we have reason to think are unlimited in this universe, and coal is not one of them. Therefore, we must not waste it.

Now the man upon whom the responsibility of acting as custodian and dispenser of our power resources de-

volves is the power plant engineer. It is his duty towards future generations to obtain the greatest possible amount of power from each pound of fuel which he uses under his boilers. An indifferent fireman might argue, "Well, I'm not paying for it—it's nothing out of my pocket if I do waste it; anyway the coal belongs to the owner of this plant. Let him do the worrying." True enough, he's not paying for it, and whether it is anything out of his pocket or not, is another matter which needs no discussion here.

But when he says the coal belongs to the owner of the plant, he is in error, for it does not. It belongs to humanity as a whole, present and future generations included, and in order that this coal may best serve the needs of humanity it must be used efficiently. The fireman is just as responsible for its efficient use as the engineer and the owner of the plant. Let him always keep in mind that every time he saves a pound of coal he is rendering a distinct service to humanity. By so doing, he will not only make himself a better fireman, but also a better man. And this applies not only to the fireman, but also to the owner, the engineer, the oilers, in fact, to everybody connected with the production and distribution of power.

The center of the earth is not an inexhaustible reservoir of coal, oil and gas, and the sooner we dispel any such illusion, the sooner we can consider ourselves worthy of the name, engineer.

Off Duty

"Hear ye! Hear ye! All downtrodden subjects are requested to participate in a public neck-tie party, to be pulled off in the square near the village pump at high noon today. His most gracious Majesty hath condescended to hang three bad eggs from the electric light pole when the whistles blow. Great festivities. Come one, come all."

These may not have been his exact words, perhaps, but in some such manner did "ye town crier" of olden times disseminate news of important events to the good citizens of medieval towns and villages. "Ye town crier" was an indispensable adjunct in his time and he occupied about the same place in the order of things that our newspapers do today. He was the official proclaimer. If there was a new tax to be levied, or a criminal to be hanged, "ye town crier" spread the welcome news. If the King singed his whiskers, or fell off his nag, or had indigestion, "ye town crier" told it to the world. He was, in other words, the official broadcaster.

And speaking of broadcasting, reminds us of the curious fact that today, after an absence of a couple of hundred years, "ye town crier" is again back on the job. He has come back—reborn, as it were. And though barely a year old, our new "crier" has already shown himself to be a likely youngster; in fact, judging him from his two-kilowatt voice, we are inclined to call him a husky baby. When he whispers, the reverberations of his powerful voice spread to the very confines of the nation. Next to him, "ye town crier" of old would look like a Russian ruble in the U. S. Mint.

Like the town crier of bygone ages, the Radiophone broadcasting station of today disseminates information and news by direct speech. But instead of addressing a local audience of fifty or a hundred, the broadcasting station commands an audience of a million or two million—a hundred million if need be. Therein lies its potential value.

Think of it! A few years hence when every average home will have its receiving set, it will be possible for a single individual, the president, for instance, to talk directly to practically every man, woman, and child in the United States. This is no idle dream; it might be done today if it were not for the fact that all the homes are not equipped for receiving radio messages. It is difficult for the mind to grasp the significance of it—addressing a hundred million people simultaneously—it almost exceeds our powers of imagination.

Whether this miracle is to be accomplished by direct radio transmission from a high powered central radio station or by simultaneously relaying the speaker's voice over land telephone lines to a dozen or more broadcasting stations located at various points throughout the country, it does not matter; it will be done.

The broadcasting feature of the radiotelephone is its greatest asset. As a means of person to person communication, it will never amount to anything. The number of radiophone messages that may be sent simultaneously is extremely limited, and even if future improvements in radio apparatus make it possible to crowd 10 or 30 different wave lengths in where we now have one, the radiotelephone will still not be able to compete with the land telephone line as far as the handling of a large number of simultaneous conversations is concerned.

But as a means of sending out information or for purposes of entertainment and education, radio has no comparison. While the city folks are certain to enjoy it, think what a boon it will be to those living in isolated sections of the country, far away from cities and towns and railroads. The farmer is the person who will be able to appreciate it the most. Conceive of the farmer in a remote section of the country sitting at his fireside in the evening listening to the world's great opera stars. Or if he wants to know the latest news of the world, he merely shifts his tuner to another wave length, and the news is brought to him fresh and full of snap. His radio set brings the whole world to his door.

What radio will mean to civilization as a whole nobody will dare to prophesy, but its influence is certain to be tremendous. New and undreamed of possibilities are unfolding themselves. Radio gives the intellect a new degree of freedom—it makes it possible for us to do things we have never done before. In 10 yr. the radio receiver will be as common in the home as the phonograph is today. As one dealer in radio apparatus puts it, "Every person with a hat on is a radio fan."

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.

Develop Water Power Sites.

Promote Health and Safety in Power Plants.

Handle Coal and Ashes Mechanically.

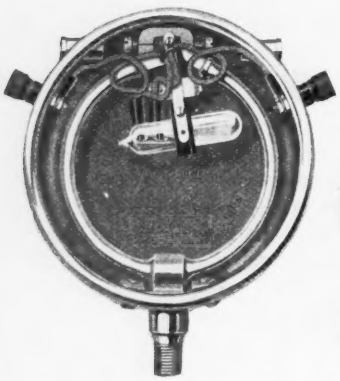
Employ Engineers for Engineering Work.

Mercoid Electrical Control Switches

IN CHEMICAL plants and other places where large quantities of explosive gases or materials are present, it is of course highly desirable to insure against all possibility of igniting such gases or materials accidentally or otherwise. In such plants, however, many of the processes involved are automatically controlled through electrical contact-making devices, by pressure, temperature, etc. Such electrical contact-making devices are made in various forms, but usually, when the circuit is opened, a small spark or arc is produced. In plants such as referred to, this spark is a source of danger and in many places extremely objectionable.

To overcome this danger, the Federal Gauge Co. and Marshalltown Mfg. Co. have developed a number of automatic control devices, in which the electrical contact is established by mercury within a sealed glass tube in the presence of an inert gas. This tube is known as the Mercoid tube and is made in various forms with various combinations of contacts.

The pressure switch shown in Fig. 1 consists of a gravity-operated mercury switch actuated by a Bourdon tube, arranged to open or close an electrical circuit at predetermined pressures.



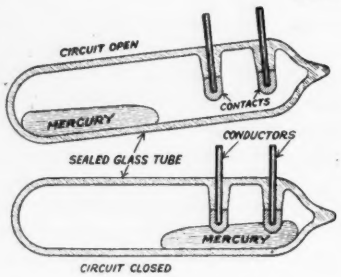


FIG. 1. FEDERAL MERCOID PRESSURE SWITCH
FIG. 2. SECTIONS OF MERCOID TUBE IN OPEN AND CLOSE POSITIONS

The circuit is made or broken within the glass tube shown in Fig. 2 in a manner which is obvious from the

FIG. 3. PHOTOGRAPH OF TWO CIRCUIT TUBES
FIG. 4. PHOTOGRAPH OF SINGLE CIRCUIT TUBE

illustration. By tilting the tube either one way or the other, the mercury flows towards or away from the contacts, thus closing or opening the circuit.

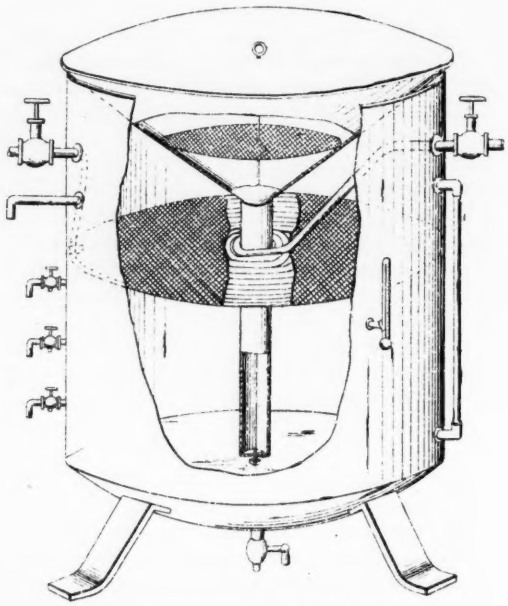
The elements contained within the tube do not combine in chemical reactions under the conditions to which they are subjected. In breaking the circuit, should a small amount of mercury be volatilized by the arc, it will condense on the walls of the sealed tube and return to its liquid state. The inert gases within the tube, being non-conductive, offer high dielectric resistance, stifling the arc instantaneously.

FIG. 5. MERCOID THREE-WAY TUBE

The maximum capacity of mercoid switches is rated at 10 amp. at 110 v. or 5 amp. at 220 v. Where large apparatus requiring greater power is to be controlled, these tubes may be used in connection with standard remote control switches of which there are many on the market.

Rose Reclaiming Oil Filter

A NOVEL TYPE of lubricating oil filter has recently been perfected in which use is made of the principle that oil undergoes a change in viscosity with a change in temperature. This is the Rose Reclaiming Lubricating Oil Filter shown in the accompanying illustration.



STEAM OPERATED OIL FILTER

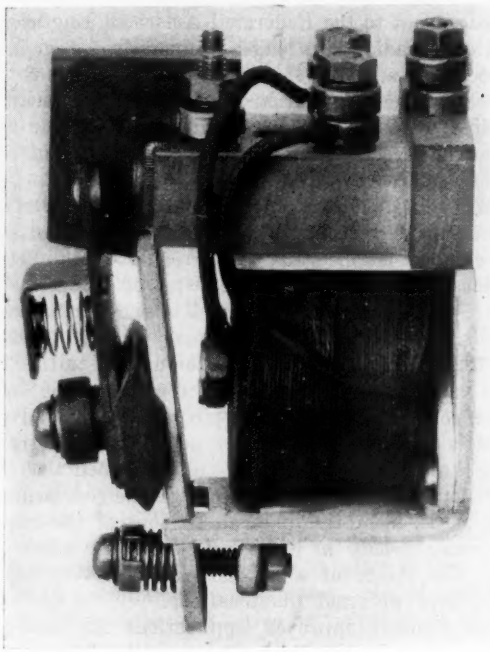
When in use, the tank is kept filled with oil to the top of the flat spiral coil through which steam is allowed to circulate. Oil to be filtered is poured into the funnel, which, as may be seen, is provided with a long spout extending to within 2 in. of the bottom of the tank. The spout, being provided with a comparatively small orifice, allows the oil to discharge very slowly. As this oil gradually rises to the top, it comes in contact with the steam heated coil, resulting in a decrease in viscosity. This causes all trash and carbon in the oil to settle to

the bottom while the clean oil rises above the coil, and finally finds it way out through an overflow pipe. Sufficient steam pressure is maintained on the coil so as to keep the temperature of the oil at 150 deg. F.

New Electric Contactors

THE GENERAL ELECTRIC CO. has recently developed a new type of small, simply constructed contactor, for use on both alternating and direct current circuits, known as the CR 2810-1265. The size of the contactors, the small amount of power they require for operation, the ease with which they may be installed and their quietness and reliability make them suitable for many different uses. Some of these are: in connection with pressure governors, float switches, automatic temperature regulating systems, electric time clocks, sign lighting systems, etc.

The contactor is single-pole with a double break, the electrical parts being insulated from the frame, so that it can be mounted wherever desired, without slate



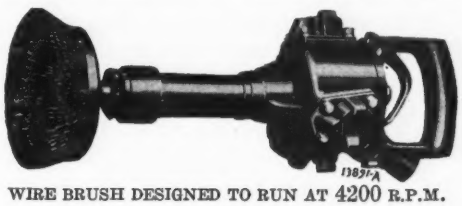
THE CR 2810-1265A CONTACTOR

bases or other insulating supports. Good contact between the moving tips and the stationary ones is insured by means of a spring, which is compressed when the contacts are open. Quick opening is secured by another spring located near the bottom of the armature, the pull of which is opposed to that of the coil magnet. The coil is held in place by two screws which bind the iron strap on which it is mounted to the base. These screws are so placed that the coil may be easily removed without disturbing the mounting of the contactor. All the terminals are mounted on top.

The current rating is 30 amp. at 110 v., and 15 amp. at 220 v., with non-inductive loads. The same contactor can also be used on 115 v., 10 amp., and 230 v., 5 amp. direct current circuits. When equipped with blowout coils, the direct current ampere rating is raised to equal that on alternating current. When used on direct current above 48 v. it is customary to connect an enamelled resistance unit in series with the coil.

New Wire Brush Cleaner

INCREASING use of air-driven wire brushes for cleaning metal surfaces has demonstrated the need of high rotative speed for the wire brush. Especially has this been true on such cleaning work where the area to be cleaned is large and a fast rate of work is required. It has been found that a wire brush turning at high speed



WIRE BRUSH DESIGNED TO RUN AT 4200 R.P.M.

cleans faster and also stands up to the severe service much better than if only revolving at 2000 to 3000 r.p.m.

The Ingersoll-Rand Co. has recently brought out a high-speed cleaner known as the No. 601 "Little David" wire brush, which has a maximum speed of 4200 r.p.m. This machine has been found successful in operation, effectively and rapidly cleaning surfaces of large area and also iron and steel castings. It has proved that it not only does a first-class cleaning job, but effects a considerable saving of time and labor as well.

The air motor is of the three-cylinder type such as are used in portable grinders and which has been thoroughly tested out in the severe service to which pneumatic grinders are subjected. Light weight has been attained by using an aluminum casing reinforced with cast-in steel bushings. The weight of the complete machine is 14 lb., the average free speed at 90 lb. air pressure, 4200 r.p.m., length overall 17½ in., and the diameter of wire brush 6 in.

Distribution of Electric Current from Hetch Hetchy Decided Upon

HETCH HETCHY hydroelectric power generated at the big Moccasin Creek plant for the construction of which $1,000,000 in contracts were let recently by the Board of Public Works, will be sold wholesale by the City of San Francisco at the plant to one of the light and power distributing companies for consumption over an extensive territory. Four generating units will be installed in the plant to start with, having a capacity of 70,000 hp. and producing more than 300,000,000 kw.-hr. of electricity annually or an amount nearly equal to the present electric supply of San Francisco. The plant will be ready for operation in about a year.

City Engineer M. M. O'Shaughnessy is now preparing an exhaustive report to the Board of Supervisors in which he deals with several alternate means of utilizing the municipal controlled power to the best interest and advantage of the city from a practical and financial standpoint.

While O'Shaughnessy will go into every phase of the big problem of disposing of this great amount of electricity in order to give the supervisors something upon

which to guide them in whatever action may be decided upon, the city engineer is of the opinion that the most logical solution would be the sale of the output of the plant. Under this tentative plan, such power as the city now requires for its present consumption in street lighting and operation of the municipal railway would be purchased from the distributing company on a basis of proportionate cost in transmitting it from the mountains.

In the alternative, the city would be obliged to construct a power transmitting line over 100 mi. long at a cost of approximately $3,000,000 and then make arrangements for disposing of the entire output. Such a plan would entail the taking over of the entire street lighting system, a proposition that would involve many complicating angles and which would even then leave a great quantity of power on the city's hands.

While this could possibly be distributed along the line between the plant and the city and the engineers figure that it would be practically impossible for many years to come to obtain a diversified distribution that would continuously consume the load. It would also involve the construction of costly transforming stations and other equipment.

It is considered that, should the city purchase the Market Street railway system, a greater quantity of the power could be utilized, but the consumption would still be uneven and therefore not practical from an economical standpoint. In any event, such a plan could not be put into effect for 7 or 8 yr., as the railway company now has power contracts covering that length of time which the city would have to assume. This power consumption amounts to more than $1,500,000 a year.

During the past year, the city derived more than $50,000 from the sale of surplus power generated at the 4400-hp. plant at Early intake. The sales represented the amount in excess of what was consumed for the operation of the entire Hetch Hetchy project, including air compressors, drills, storage batteries dump cars from the tunnel, other machinery and lighting of the works. It is estimated that by the sale of the surplus power from the big Moccasin Creek plant sufficient revenue would be received to pay for a great percentage of the interest on the bonds used in construction of the water and electric project until such time as the city is prepared to consume the output of both.

This is the analysis of the situation made by city officials who have been familiar with the development of the Hetch Hetchy project.

Spring Meeting of the A. S. M. E.

JOHN LYLE HARRINGTON of Kansas City, Mo., will be the next president of the American Society of Mechanical Engineers, succeeding Dean Dexter S. Kimball of Cornell University. Mr. Harrington headed the ticket selected by the nominating committee of the society, whose report was presented at the Spring Meeting held in Atlanta, Ga., May 8 to 11. Mr. Harrington is a consulting engineer of national reputation and is a member of the firm of Harrington, Howard & Ash. Mr. Harrington and the other officers named will be elected by mail ballot of the society's membership and will take office at the close of the next annual meeting in New York City in December.

Vice-presidents of the society were chosen as follows: W. S. Finlay, Jr., New York; William H. Kenerson, Providence, R. I.; Earl F. Scott, Atlanta, Ga., and H. H. Vaughan, Montreal, Canada.

These managers were selected: A. G. Christie, Baltimore, Md.; James H. Herron, Cleveland; Roy V. Wright, New York.

William H. Wiley is continued as treasurer and the following will serve as delegates to the American Engineering Council:

John Lyle Harrington, Chairman; L. P. Alford, New York; A. M. Greene, Jr., Troy, N. Y.; Fred J. Miller, New York; Max Toltz, St. Paul, Minn.. Fred R. Low, New York; S. W. Stratton, Washington, D. C.; Edwards R. Fish, St. Louis, Mo.; Edwin B. Katte, New York.

Albert Kingsbury of Philadelphia was appointed for a term of three years to represent the society on the National Research Council, Engineering Division.

The proposed constitution was adopted as a whole after having been modified by the adoption of several amendments.

The Council favored application to the Government for assignment to the Federated American Engineering Societies of radio wave length exclusively for engineering societies, and the society's secretary learned that prospective new legislation may make assignment of exclusive wave lengths for engineering possible. All commercial broadcasting must now be done on wave lengths of three hundred and sixty meters.

Professor Kenerson reported progress in the matter of securing suggestions for the award of a scholarship in mechanical engineering, at the request of the Schools of Mines, Engineering and Chemistry of Columbia University. The report was referred to the Committee on Awards. The scholarship, beginning with the academic year 1922-23, pays $350 toward the annual tuition fees, which vary from $340 to $360, according to the details of the course selected. The purpose of this advance course is to turn out a high type of engineer trained in the humanities as well as the fundamentals of his profession. It is hoped that through the representative A. S. M. E. membership in all sections of the country there may result a widespread interest which will assure the choice of a candidate of the very highest mental and personal qualifications."

The Council approved applications for new local sections from Dallas, Tex.; Chattanooga, Tenn.; Louisville, Ky.; and the state of Nebraska.

The Atlanta meeting was one of the most productive in the history of the society and attracted nation-wide interest, and opened up to the engineers of the country, it was said in a statement issued by the society.

Among the leading papers of the meeting was one by George H. Harris, of Atlanta, who declared that management must make greater efforts to do its share in maintaining the three-legged table that supports industry.

The South, Mr. Harris declared, was forging to the front in the cotton industry because of advantages of labor, accessibility of raw material and absence of discontent which handicaps "the union-ridden mills of New England."

"Reduction of Fuel Wastes in the Steel Industry" was the topic of F. G. Cutler of Ensley, Ala., whose

paper set forth the economy of utilizing blast-furnace gas, at one time considered to be of little material value, in reducing the wastes of the steel industry. "There are," he said, "in this and in all allied by-product industry, opportunities for reduction in the consumption of fuel."

Major J. K. Clement, Ordnance Department, U. S. A., in a paper on "The Muscle Shoals Plant and the Nitrogen Supply," said that the operation of the Muscle Shoals plant should contribute materially toward the building up of the nitrogen-fixation industry.

Charles G. Adsit of Atlanta, speaking on "Power Development in the Southeast," said that the public had been misled on the Muscle Shoals project, adding: "There are many undeveloped water-power sites in the Southeast which can be developed on a commercial basis to much greater advantage than the development at Muscle Shoals. The South is open for great industrial development, as it either has or can develop the necessary hydroelectric power, and enjoys the natural advantage of an even and salubrious climate, together with a large store of raw materials in both its agricultural and mineral resources."

Curtis A. Mees of Charlotte, N. C., delivered an address on "Economics of Water-Power Development," in which he said: "Water-power development does pay —never big, however, but even very small plants of high unit cost entirely justify their existence. It does not pay at this time because the public will not invest in securities at interest or dividend rates which permit the financing of such undertakings on a basis of present permissible earnings."

An important development of the meeting was the decision to support the campaign of the F. A. E. S. for the establishment of a National Department of Public Works. The next spring meeting of the society will be held in Montreal.

Le Grand Skinner Dies

LE GRAND SKINNER, inventor, manufacturer, financier and president and founder of the Skinner Engine Co. of Erie, Pa., died at Cambridge Springs, May 9, at the age of 76, after a long illness caused by a complication of diseases. His ill health had forced him to relinquish active participation in his business for some time before his death.

In 1868 Mr. Skinner built his first engine and in 1871 began the manufacture of steam engines at Chittenago, N. Y. Later he established his business in Chicago, but in 1873 moved to Erie, where he opened a small manufacturing plant. Since that time the business has grown to such an extent that now it is one of the largest industries in Erie. He was also one of the organizers of the Union Iron Works, another of the big manufacturing plants of Erie.

Mr. Skinner contributed largely to the improvement of the reciprocating steam engine, and, due to his efforts, the use of the unaflow principle and poppet valves has been greatly increased. His latest and probably most important achievement was the production of what is known to the trade as the Universal Unaflow engine.

Appreciating his knowledge of steam engineering, the Government requested that his company design and build a marine engine that would be more economical than the then existing types, and Government tests of this engine proved most gratifying.

Mr. Skinner is survived by his widow and his one son, Allan D. Skinner, who has for some time been closely identified with the company and has for the last few years been the active head of that organization.

News Notes

THE DODGE SALES AND ENGINEERING CO., Mishawaka, Ind., announce the removal of its New York City branch from 21 Murray St. to the new Dodge building, located at the corner of Park Place, W. Broadway and Murray St., and known as 53 Park Place.

THE CUNNINGHAM MACHINE WORKS CORPORATION is being formed to take over the old Cunningham Machinery Co., of Shreveport, La., making a specialty of power plant equipment in that territory. G. F. Cunningham, formerly a mechanical engineer of Cleveland and Orrville, Ohio, will be in charge of the engineering department.

ANNOUNCEMENT IS made of the incorporation of the Raymond Brothers Engineering Co., Chicago, for the manufacture of equipment for pulverized coal systems for the utilization of pulverized coal as fuel in metallurgical operations, cement plants, and under boilers in power plants, and for the designing and installation of such systems. The new company takes over the business of the American Industrial Engineering Co. of Chicago, which has made a number of such installations, and L. H. Bergman, who has been secretary and chief engineer of the American Industrial Engineering Company, will remain as general manager of the new company, which is a subsidiary corporation of the Raymond Brothers Impact Pulverizer Company, Chicago, and will have general offices at 1315 North Branch Street, Chicago.

THE CITY of Abbeville, La., has been suffering from light, water and power complaint for some time, but treatment has now been prescribed in the shape of a complete new modern central station, which will mean excellent accommodations for years to come. Abbeville has no street lights because there is insufficient power in the existing plant, and the city has been penalized heavily by the Fire Underwriters because the water pumping equipment is inadequate. The present administration was elected on a platform which guaranteed correction of these conditions, and the officials have made good their promises.

A bond issue of $125,000 was authorized to finance the work, and all of the necessary machinery has been purchased. Three three-cylinder Fulton Diesel oil engines, developing 175 b.hp. each, will be installed, with direct connected generators and exciters. The pumping equipment will consist of two 1000-g.p.m. Dayton-Dowd Underwriters' fire pumps and two 300-g.p.m. domestic service pumps, all motor driven. Water will be pumped from deep wells by the air-lift system with two slow-speed air compressors, also electrically driven.

CONTRACT HAS been awarded to Dwight P. Robinson & Co., New York, for the construction of a building to accommodate American commercial exhibits at the Brazilian Centennial Exposition to be held in Rio de Janeiro beginning Sept. 7. The building, which will be the "unofficial" exhibit building, will be constructed of American materials as far as possible. It will be purely a com-

mercial proposition, having no direct connection with the exhibition plans of the American Government under the appropriation of $1,000,000 made by Congress recently.

U. S. Civil Service Commission announces an examination, June 21-22 and Aug. 9-10, for Laboratorian, Chemical, Physical, Engineering, to fill vacancies in the Federal classified service throughout the United States, including the Departmental Service, Washington, D. C., at $1200 to $1500 a year, or higher or lower salaries. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. Competitors will be rated on mathematics (through trigonometry), elementary physics, optional subjects, chemistry, physics or elementary engineering, education, training and experience. Applicants must have reached their eighteenth but not their forty-fifth birthday on the date of examination. These age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating examination title.

The Denver Gas & Electric Co. has asked the federal power commission for permission to build a dam 230 ft. high across the Colorado River in Gore Canon, the purpose being to erect a hydroelectric station. Engineers are divided upon the practicability of the scheme, many contending that such a high dam would inundate the Denver & Salt Lake Railroad tracks (Moffatt Route), and claim that a lower dam would be practical and perform what is expected. If the project becomes a reality, power from this station may be used to electrify the Moffatt Railroad, the country for many miles around and will be a paying venture from the start. Gore Canon is about 140 mi. from Denver, or 70 mi. from the west bore of the proposed Moffatt tunnel, and it is one of the most beautiful spots in the state.

Elliott Company announces the following changes in its sales organization: W. E. Widau, formerly of the Cleveland district office, has been made assistant general sales manager, with office at the Company's general office, Jeanette, Pa. Recent additions to the sales force are the following: J. R. Lemon and S. B. Overton have been added to the sales force of the Philadelphia district office. R. K. Williams goes to the Cleveland district office, and W. T. Bickel to the Pittsburgh district office.

The American Supply Co., Providence, R. I., has been appointed agent for the Providence district to represent the Quigley Furnace Specialties Co. of New York.

C. A. Chapman, Inc., announces the twenty-second anniversary of Chapman Service as industrial and power engineers, also the opening of its new plant in the Madison Terminal building, 9 South Clinton St., Chicago.

Ambest Metallic Packing, which has heretofore been manufactured by the Eureka Packing Co., will hereafter be made and supplied by the Ambest Metallic Packing Co., 154 West Broadway, New York, N. Y. The new company will specialize on this product and its improvement.

Catalog Notes

Bulletin No. 48,716, issued by the Sprague Electric Works of the General Electric Co., describes The Sprague Electric Dynamometer. These machines are built in a number of different sizes for a diversity of application and adapted to testing both high and low speed apparatus.

Apparatus for Heat Transfer, a bulletin recently produced by the Schutte & Koerting Co., is a collection of the company's bulletins on this type of apparatus including evaporators, distillers, boiler feed water heaters, grease extractors, water heaters, fuel oil heaters, air heaters, air coolers, oil coolers, circulating water coolers, radiators, inter and after coolers, etc.

These bulletins not only describe and explain the uses of the various pieces of apparatus, but they also go into some detail on the results theoretically attainable and those that may be expected in practice.

As an example, the information given concerning boiler feed water heaters includes a chart for finding the maximum fuel saving possible for certain conditions of steam pressure quality or superheat, and initial and final feed temperatures. A graph is shown, giving the coefficient of heat transfer in B.t.u. per sq. ft. of heating surface per degree mean difference in temperature between water and steam per hour, for varying water velocity through the tubes. Another shows the friction drop and temperature rise in the heater for different lengths of tubes for one given water velocity.

Similar information and charts are given for other apparatus described.

Westinghouse meter service switches are described and illustrated in Circular No. 4484, recently issued by the Westinghouse Electric & Manufacturing Co. The switches are designed to meet every condition encountered by central stations in supplying service to homes and apartment houses and they can be used in connection with standard makes of meters on the market, or independently, if desired.

Bulletins were lately issued by The Defender Automatic Regulator Co., St. Louis, Mo., as follows: Bulletin No. 99, Defender Model D three-tube draft and pressure gage for boilers with low pressure in the forced draft, or for any type of forced draft stokers that carry a low pressure in the wind box; No. 100, Defender improved type U gages, open and closed front types, equipped with improved single column direct reading adjustable scales; No. 105, Defender direct reading seven-tube combustion draft and pressure gage for five-compartment forced draft chain grate stokers that have five separate wind boxes or compartments.

Uehling Instrument Co.'s new Bulletin No. 112 covers Uehling CO_2 recording equipment, including the recently developed "Pyro-porus" filter for keeping the gas sampling lines clean. Other noteworthy features discussed are the separate recorder for the engineer's office and indicator for the boiler front, continuous (not intermittent) chart record and dry method of absorption.

Kieley & Mueller steam, water and air specialties, for use in connection with power, heating and plumbing installations, are illustrated and described in a 316-page catalog from Kieley & Mueller, Inc., New York.

Boiler Installations for Textile Mills, Bulletin No. 51 of Heine Boiler Co., St. Louis, Mo., discusses the utilization of steam in textile mills and illustrates Heine boiler installations in plants of various manufacturing companies.